EFFECTS OF SELF-WEIGHING AND VISUAL FEEDBACK ON WEIGHT CONTROL IN ADULTS

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EFFECTS OF SELF-WEIGHING AND VISUAL FEEDBACK

ON WEIGHT CONTROL IN ADULTS

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Age-related weight gain presents a threat to public health, as it contributes to increasing incidence of overweight and obesity. The Caloric Titration Method (CTM) is a technique for weight control consisting of daily self-weighing and viewing an individualized graph of weight over time. This dissertation examines use of the CTM for weight loss in overweight and obese adults, prevention of weight regain after loss, and prevention of age-related weight gain in normal weight adults. In addition, analyses exploring psychological factors, their evolution over time and the relationship between these psychological factors and weight change are performed and discussed. Finally, a phenomenological approach is taken to understand how use of the CTM facilitates a self-directed learning process. To investigate potential mechanisms of the CTM, results of a quasi-experimental study are reported. Findings support the CTM as an effective tool for minimal weight reduction over a one-year period in obese and overweight adults, and maintenance of this loss over a second year. The CTM also was successful in preventing age-related weight gain in normal weight women over a two-year period. A sense of being in control of body weight was associated with success in using the CTM. Because the CTM promotes individuals to discover unique approaches to weight control, participants engaged in self-directed learning processes. Interview data from participants that continued using the CTM and those that

withdrew from the study revealed self-directed learning processes. Future research directions include use of the CTM in diverse populations as evidence from these studies support use of this technique at a larger level to help individuals control body weight. If successful, this method could decrease the prevalence of obesity.

BIOGRAPHICAL SKETCH

Carly Rachael Pacanowski studied Nutritional Sciences at the Pennsylvania State University. She received a Bachelor's of Science degree in December of 2006 and graduated with minors in Architectural History and Psychology. During the summer after her junior year, Carly conducted her undergraduate thesis research in Rome, Italy, on the topic of perceptions of the Mediterranean Diet.

From 2007 to 2013, Carly was enrolled in the Division of Nutritional Sciences' doctoral program at Cornell University. In 2009, she took a brief leave from her doctoral studies to complete the Cornell Dietetic Internship program, where she her earned her certification as a Registered Dietitian. Most recently, Carly defended her doctoral dissertation, and earned her PhD, advised by David Levitsky, in the Division of Nutritional Sciences.

Carly's future plans include continuing to research self-weighing and body weight regulation as a National Institutes of Health postdoctoral fellow in Minneapolis, MN, and collaborating with Dr. David Levitsky on numerous ongoing projects. Carly enjoys exercising, art, shopping, coffee, wine, vegetarian food, and meeting people. She loves animals, especially cats.

This dissertation is dedicated, in full, to Dr. David Levitsky. David exudes a passion for discovery and a love for his work amidst any potentially threatening political or disconcerting life circumstances. He is truly admirable and a role model. I have a pretty vivid imagination and I cannot imagine a better advisor or lifelong friend. For all that you have taught me, I am eternally grateful.

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LIST OF SYMBOLS & ABBREVIATIONS

*	multiply or by (interaction term)
±	plus or minus
Δ	Change in
BMI	Body Mass Index
BP	Bodily Pain
CTM	Caloric Titration Method
GH	General Health
kg(s)	kilogram(s)
lb(s)	pounds
LOCF	Last observation carried forward
LOC	Locus of control
MCS	Mental Component Summary
MH	Mental Health
NHANES	National Health and Nutrition Examination Survey
NS	not significant
NWCR	National Weight Control Registry
PCS	Physical Component Summary
PI	Principal Investigator
PF	Physical Functioning
PPTIDS	Participant IDs
randcode	treatment group assignment (experimental or control)
RE	Role Emotional
RP	Role Physical
SD	Standard Deviation
SF	Social Functioning

SF-36	Short Form -36 Item Survey
SPSS	Statisitcal Package for the Social Sciences
TFEQ	Three Factor Eating Questionnaire
TTM	Transtheoretical model
tx	treatment
US	United States
USDA	United States Department of Agriculture
VT	Vitality
WLOC	Weight locus of control

INTRODUCTION

The United States (US) and world populations have been gaining weight over the past several decades. This is evident by both cross sectional (Centers for Disease Control and Prevention, 2012; Lee et al., 2010; World Health Organization, 2013) and longitudinal data (Colditz et al., 1990; Kuczmarski, 1992; Sutin, Ferrucci, Zonderman, & Terracciano, 2011). Although age-related weight gain prevention is not a new idea (Jeffery & French, 1999), only one study (Lombard, Deeks, Jolley, Ball, & Teede, 2010) used an intervention that was effective in preventing weight gain and would be feasible to disseminate at the population level.

Using first semester college freshmen as a model for weight gain of the population, Levitsky and colleagues demonstrated that self-weighing and graphical feedback of weight was effective to prevent otherwise experienced freshman weight gain (Levitsky, Garay, Nausbaum, Neighbors, & Dellavalle, 2006). This dissertation centers on examining this method, termed the Caloric Titration Method (CTM), in adults. Chapter 1 critically analyzes studies published about self-weighing and clarifies a need for Chapter 2, which is a study designed to independently test the CTM to reduce body weight in obese and overweight adults over a one year period. Chapter 2 also examines if the CTM is effective in preventing weight regain after the first year of loss, to complete a two year study. Chapter 3 analyzes select psychological factors (perceived weight control, self mastery, and quality of life) in relationship to weight and the CTM over a 2-year time frame. Chapter 4 examines the CTM in a different population, normal weight, middle-aged females, for preventing age-related weight gain over a 2-year period and also examines psychological variables. Chapter 5 investigates a potential mechanism of the CTM by experimentally manipulating weighing to see whether individuals' perception of their eating behaviors change as a result. Chapter 6 contributes a richer understanding of the participant's perspective when using the CTM by qualitatively analyzing the self-directed learning process participants engaged in when finding what worked for them as individuals. Finally, Chapter 7 summarizes these studies.

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CHAPTER 1

FREQUENT SELF-WEIGHING TO CONTROL BODY WEIGHT IN ADULTS: A CRITICAL REVIEW

Introduction

The role of self-weighing as a viable tool for weight management has been evolving quite rapidly. Until recently, frequent weighing has often been discouraged. For years, commercial programs advised against self-weighing more than once a week. Cognitive–behavioral interventions for weight loss recommend at most weekly weighing because of the belief that individuals may be discouraged by negligible loses in their weight over short periods of time. It was thought that weekly weigh-ins may motivate people to ‘beat the scale’ by engaging in unhealthful weight control practices leading up to the weight measurement (Heckerman, Brownell, & Westlake, 1978).

However, increasing evidence over the last few decades suggests that frequent weighing is a hallmark of successful dieters and weight maintainers. Frequent weighing also may help prevent age-related weight gain: a key factor in quelling the rising culture of obesity in America.

This chapter expands on a previous systematic review of self-weighing as a technique to control body weight (Vanwormer, French, Pereira, & Welsh, 2008) by describing the history of frequent self-weighing and contrasting its effectiveness in preventing weight regain or age-related weight gain to its ineffectiveness as an adjunct to behavioral weight loss methods. The possible beneficial and harmful effects of frequent self-weighing will be evaluated as well as the putative mechanisms through which frequent weighing may increase the ability to control weight.

Methods

Since this review has such a particular topic, searching beyond the broad key words search of "self-weighing" or "weigh*" was necessary. This preliminary step allowed us to address seminal works on the topic of self-weighing. Once seminal works were identified, their references were tracked backwards until we found the earliest mention we were able to of having participants weigh themselves for the purposes of weight control in the published literature (Stuart, 1967). This work was forward-tracked using multiple databases including: Summon, Google Scholar, and Web of Science, as the latter two draw from different archives. Reference librarians were consulted about the extent of overlap between search engines and obtaining the broadest view possible. In addition to forward tracking the Stuart article, an exhaustive literature review was performed on Romanczyk (1974). This particular article was cited 7 times in Scopus (summon), 55 times in Web of Science, and 79 times in Google Scholar. The number of times Stuart (1967) was cited in Scopus was not listed; the article was cited 340 times in Web of Science and 573 times in Google Scholar, reinforcing the importance of using multiple databases.

When forward tracking, every citing work was examined. If the title and abstract described a different type of self-monitoring other than self-weighing (e.g. cigarette smoking cessation) or the unit of analysis was something other than adult humans or published in a journal concerned with findings outside the scope of this review (e.g. participants are children, animals, or the article is printed in the Journal of Dentistry for Children), the reference was excluded. The article was also required to be in English and to have undergone peer-review prior to publication. Also, conference abstracts were considered along with theses and dissertations. If the article met these initial criteria, then it was searched for “weigh” or “weighing” to determine the context in which weighing was discussed. The place where the article cited the seminal work (e.g. (Romanczyk, 1974; R. B. Stuart, 1996)) was identified to determine accuracy and context of the citation. Articles not available electronically were located in their original place of hardcopy publication and scanned from the Cornell Library, or requested through Interlibrary Loan. Theses and dissertations were also examined and microfilm was used to determine if these works added any additional information to the search. Towards the end of the search, saturation was reached, indicating that an extensive review of the printed published literature had been conducted.

To continually check for any missing literature, all included articles were tracked forward and backward to see if any additional relevant references appeared. This searching is through June 2013.

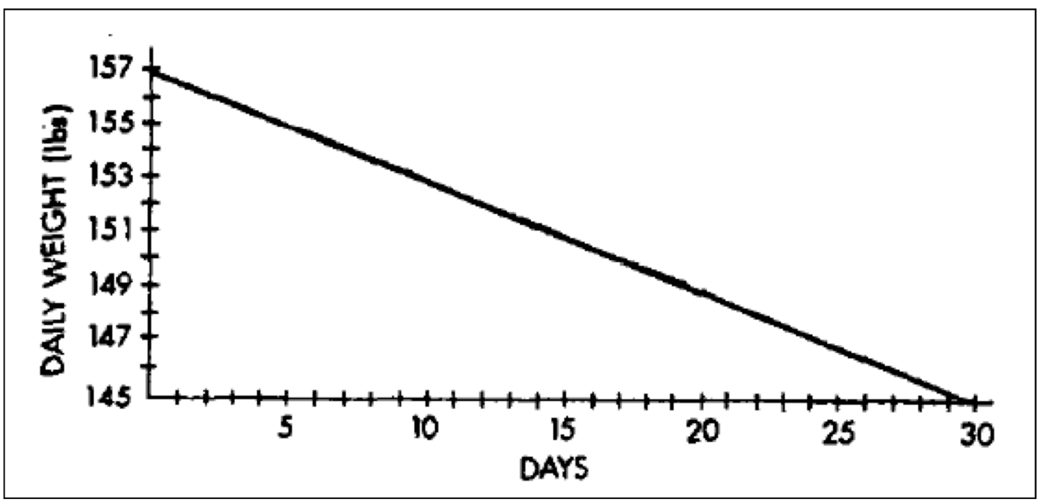
Results &Discussion

Early reports of frequent self-weighing to facilitate weight loss

In 1967, Stuart published an article entitled “Behavioral Control of Overeating”. As part of a behavioral plan to lose weight, his technique had patients weigh themselves four times a day: “before breakfast, after breakfast, after lunch, and before bedtime” (Stuart, 1967, p.358). Weight was charted over time to visualize the participant’s progress. Based on behavioral theory, the weighing was assumed to serve as a mildly aversive stimulus and a reinforcer by helping patients notice deviations in their weight throughout the day. This cognitive awareness was thought to assist participants in stabilizing their eating patterns by showing direct evidence of the effect of eating and drinking pattern on their weight. Stuart believed that this would minimize overeating, and remind patients of the weight loss program in which they were enrolled.

Soon after Stuart's behavioral approach was published, Fisher and colleagues (Fisher, Green, Friedling, Levenkron, & Porter, 1976) published the first study of the effectiveness of self-weighing to produce weight loss. They reported the weight loss of eleven case studies in which the participants were instructed to weigh themselves daily and graph their weight on a chart. The graph also contained a line connecting the subjects' starting weight to a goal weight approximately 8 to 12 lbs. lower than their starting weight over the course of about 30 days (Fisher et al., 1976). Figure 1.1 is taken from the original publication.

Figure 1.1



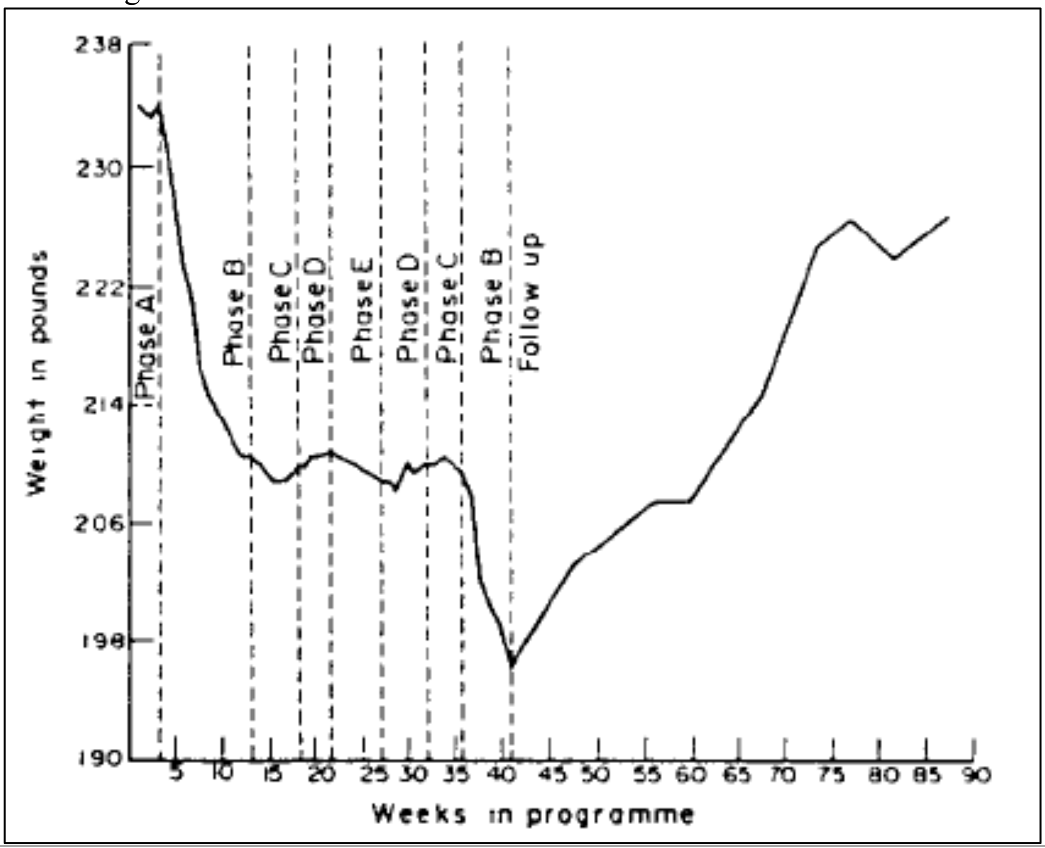
Graph indicating rate of weight loss on which participants were supposed to plot their daily weight. From (Fisher et al., 1976).

The descending line on the graph started two pounds above the participant's starting weight and continued diagonally to their target weight in order to give the participants a sense of success at the beginning of treatment. Participants were not given specific dietary or physical activity instructions but were simply told to graph their weight daily on this chart and to try to keep their weight below the sloped goal line. Ten of the 11 participants lost an average of 9.6 lbs. over a period of 39 days.

Although the results of Fisher et al.'s publication seemed to substantiate self-weighing as a technique to aid weight reduction, it used case studies (Fisher et al., 1976). Because no control group was used, a causal inference cannot be made as to the effectiveness of self-weighing. A few years later, Loro, Fisher and Levenkron (1979) performed one of the first experimental tests of the effectiveness of self-weighing as an adjunct to other behaviors to facilitate weight loss. They compared three different treatments: one focused on controlling eating in response to external eating cues, one focused on changing eating behavior, and one centered on enabling participants to initiate their own treatment (Loro et al., 1979). This self-initiated treatment group was given an informational booklet about self-control and instructed to employ daily weighing and charting using a personalized target weight line similar to that used by Fisher et al. (1976). All participants signed treatment contracts, made refundable pre-program deposits prior to treatment to minimize attrition, and received group counseling and nutrition information. The participants in eating behavior control groups were also asked to weigh and graph their weight, but their graph did not contain the line representing the targeted rate of weight loss. Adding the target weight to the graph had no effect on the average amount of weight lost. In fact, after six weeks, no difference in weight loss between any of the three treatments was observed.

Stuart's 'weighing four times a day and graphing' approach was further tested along with other self-monitoring techniques in a clinical study of a mildly retarded adult female conducted in a residential training center (Joachim, 1977). The study was divided into nine phases as indicated in Figure 1.2.

Figure 1.2



Mean body weight as a function of time and phase. From (Joachim, 1977)

In phase B, the patient weighed herself four times a day and recorded the time, the amount and the circumstances during which she ate or drank – a procedure modeled after Stuart. Phase B resulted in the greatest weight loss (21 lbs in 10 weeks). Then, in various phases, portions of the behavioral program were eliminated, except for the frequent weighing, in order to estimate the contribution of each strategy to the overall effectiveness of frequent weighing. Although none of the aspects of behavioral modification had an appreciable effect on body weight, weight regain was successfully prevented. Re-imposing all of the elements of the original behavioral modification procedure (Phase B) again seemed to stimulate further weight loss. Interestingly, when all treatments were terminated, including the frequent self-weighing, at 40 weeks, weight returned to its pretreatment level.

Using a more conventional experimental design, Mahoney and colleagues (Mahoney, Moura, & Wade, 1973) compared self-weighing to other behavioral treatment methods used to help obese patients lose weight. The five strategies studied included (a) self-reward, (b) self-punishment, (c) self-reward and self-punishment, (d) self-monitoring and (e) an information control group (Mahoney et al., 1973). Groups (a to d) were instructed to weigh themselves daily and chart their weight. Twice a week their weight was measured by the experimenters. The self-reward and self-punishment groups used financial incentives as motivational strategies in addition to the self-weighing. At the end of four weeks, the weight loss of the self-monitoring group was significantly less than the self-reward group. There was no mention of whether the weight loss of the self-monitoring group (which included self-weighing) was different from the control group. Mahoney and colleagues found weight loss of the self-monitoring group to be less than half of what was achieved by two self-reward groups (one self-reward and one self-reward plus self-punishment) after four months (Mahoney et al., 1973). Thus, the results of this study suggest that self-weighing by itself, without the use of either self-reward or self-punishment, did not produce a significant weight loss.

The lack of effectiveness of self-weighing compared to other kinds of self-control techniques used to promote weight loss was corroborated in a succeeding study by Mahoney (Mahoney, 1974). Using obese patients, he compared the following interventions: (a) self-reward for weight loss, (b) self-reward for habit improvement, (c) self-monitoring, and (d) a delayed treatment control group (Mahoney, 1974). Similar methods as outlined in the previous study were used to produce the groups. All three groups lost significantly more weight than the self-monitoring group, the group that used self-weighing.

Similarly, Romanczyk (Romanczyk, 1974) found that frequent self-weighing did not enhance behavioral modification techniques to facilitate weight loss in a group of overweight people. His study was designed to differentiate between the relative contributions of (a) no treatment, (b) self-weighing, (c) self-monitoring caloric intake and self-weighing, (d) behavior management and stimulus control, and (e) behavior management and stimulus control with self-weighing and self-monitoring caloric intake. Adding self-weighing to weight reduction treatments offered no benefit to any the weight loss procedures under any condition. Although not tested statistically, it is interesting to note that controls gained about 0.5 lbs during the four-week trial whereas the group instructed to only weigh themselves gained 0.09 lbs during this period.[1]

The inability of self-weighing to enhance weight loss among a group of overweight participants was also reported by Heckerman, Brownell and Westlake (Heckerman, Brownell, & Westlake, 1978). They tested whether it was more

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[1]Much of the same data were published a year earlier (Romanczyk, 1973).

beneficial for people who wanted to lose weight to focus on their weight or to focus on the behaviors that determine their weight such as eating and exercise. They directed participants to either weigh themselves between weekly weigh-ins or to avoid weighing themselves. Instead of focusing on their weight, the latter group was asked to focus on making behavioral changes for the 10 weeks of the weight loss study. Both groups lost a significant amount of weight. Frequent weighing did not facilitate weight loss at 2.5 months (intervention) or at follow-up at 3.5 months and 6 months.

Quayle and Powers (1979) examined the use of daily weighing and charting of weight as part of a sequence of strategies used for weight reduction in six overweight students. The daily weight monitoring stage lasted for a minimum of 2 weeks, with participants moving to the next stage when their weight was stable. Significant weight loss was not observed in any of the participants for the weight monitoring stage (average weight change -0.2 pounds). However, when an additional self-monitoring technique, self-recording of bites, was introduced, an increase in weight loss (-2.9 lb.) emerged (Quayle & Powers, 1979).

Contrary to these findings that suggest that self-weighing is not helpful as an adjunct to weight loss, a recent study by Oshima et al. (Oshima, Matsuoka, & Sakane, 2012) suggests that daily self-weighing alone may be sufficient to impose a weight loss without the need any instructions for dieting or exercise. Oshima and colleagues examined the effects of weighing on a group of overweight adults who were instructed to weigh themselves either (a) at the same time every day or (b) twice each day, once immediately after rising from bed then again immediately before going to bed at night. In addition, the twice-daily weighing group viewed a graph of their weight and their "target" weight (5% less than starting weight) on a liquid crystal display screen at each weighing. The group that weighed themselves twice each day and viewed a graph of their weight lost 2.7 ± 9.7 kg and the group that weighed themselves once each day lost 1.0 ± 1.4 kg, a statistically significant difference ($p<0.05$) at the end of 12 weeks. The weight loss of both groups was statistically different from zero ($p<0.001$). Though this study's results present an anomaly when considering the previously discussed literature, it is possible that visual feedback enhances the effect of self-weighing on weight loss.

As suggested by the review of studies using frequent self-weighing as an adjunct to other kinds of weight reduction techniques, it is fairly clear that with the exception of the more recent study by Oshima et al. (2012), frequent self-weighing did not facilitate weight loss. In fact there are several indications that it actually diminished the rate of weight loss.

Self-weighing as a correlate of weight control

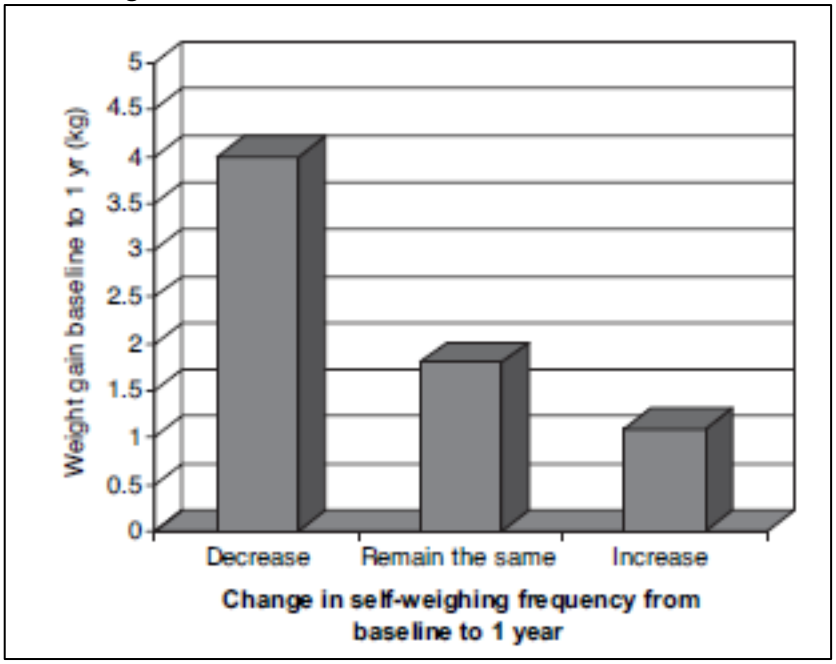
By the end of the 1970s, lack of success of frequent self-weighing to facilitate weight loss appears to have drastically reduced the number of experimental studies that examined the role of self-weighing to control weight. Interest in self-weighing was reignited by an observational study conducted by Jeffery and colleagues (Jeffery et al., 1984). Using questionnaires, they examined the behavior of a group of middle-aged men who completed a 15-week weight reduction treatment with a two-year follow-up. They observed that the more frequently the men reported having weighed themselves, the more successful they were at losing weight. Even more impressive was the finding that those who reported weighing themselves more frequently maintained their weight loss one year after completing the weight loss treatment, although the difference disappeared by the end of the second year.

One of the first published studies regarding the prevention of age-related weight gain was published in 1997 by Jeffery and French (Jeffery & French, 1997) as a study of weight-gain prevention. They randomly assigned participants to one of three conditions. Two of the intervention groups received educational information through a newsletter describing techniques to avoid gaining weight. The information focused on five strategies, one of which was frequent weighing (at least once a week). One of these two intervention groups received the same information but, in addition, was offered a prize (incentive) for following the instructions. The third group acted as a non-intervention control group. The participants were examined at the end of one year. None of the conditions prevented age-related weight gain. However, an analysis of the aggregated data, regardless of treatment group, indicated that the more frequently participants reported having weighed themselves, the less weight they gained (r values -0.14 to -0.21; p values <0.05) (Jeffery & French, 1997). This negative correlation between frequency of self-weighing and weight gain remained highly significant ($p < 0.01$) for each of the three years of the study [(year 1 (-0.16), year 2 (-0.15), year 3 (-0.11), as well as over the entire 3-year examination period (-0.11) (Jeffery & French, 1999).

In the same year researchers reported the results of a group of exceptional individuals. Self-enrolled members of the National Weight Control Registry (NWCR) had to verify that they had lost at least 30 pounds and successfully maintained the weight loss for at least one year. An examination of the behaviors of this group revealed that 75 percent of these successful weight loss maintainers reported that they weighed themselves at least once per week (Klem, Wing, McGuire, Seagle, & Hill, 1997). This high rate of self-weighing was confirmed 10 years later in a larger study of the participants in the NWCR where 79 percent of successful weight maintainers reported that they weighed themselves at least once a week (Butryn, Phelan, Hill, & Wing, 2007).

Succeeding examinations of the NWCR and other data corroborate a relationship between successful maintenance of weight loss and the frequency of self-weighing. In a large telephone survey of the US population, McGuire et al. (1999) confirmed that the frequency of self-weighing in successful weight loss maintainers (55.1%) was significantly greater than the population at large (34.5%) (McGuire, Wing, & Hill, 1999). This comparison was important because the studies of the NWCR did not have an estimate of the frequency of weighing among controls or people who did not lose weight. Moreover from the telephone survey, it was observed that people who tried to lose weight but regained their weight, reported a significantly lower rate of self-weighing (35.7%) than the successful weight loss maintainers, a finding very similar to that observed by the follow-up of the NWCR as depicted in Figure 1.3 (Butryn et al., 2007).

Figure 1.3



Mean weight gain as a function of change in the frequency of weighing. From (Butryn et al., 2007).

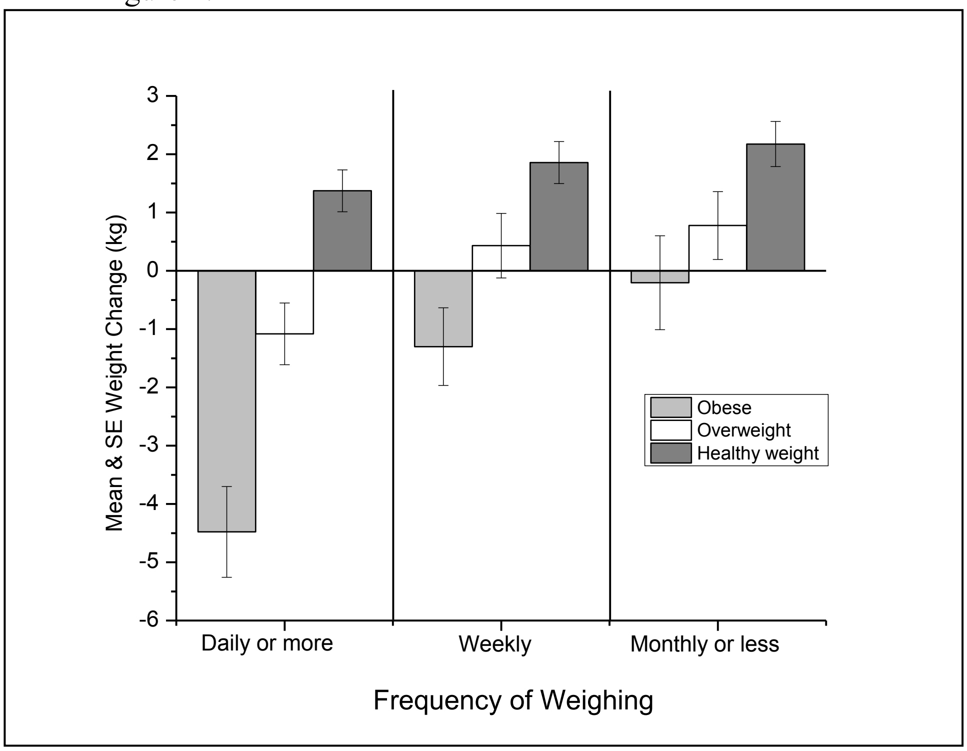
Those who decreased their frequency of self-weighing gained more weight than those who increased their frequency of self-weighing. These results, however, conflict with the findings of Kayman et al. (1990) who reported no difference in the reported frequency of self-weighing between a group of weight maintainers and a group of weight re-gainers (Kayman, Bruvold, & Stern, 1990). However, Kayman's sample size was small (n=64) compared to the NWCR (n=3003) and his response measure was dichotomous (watches weight on scale: yes/no) rather than offering more than two categories.

More recently, Linde et al. (Linde, Jeffery, French, Pronk, & Boyle, 2005) continued these observations by comparing the reported behaviors of successful and unsuccessful obese participants in a large-scale weight loss study (Weigh To Be) and a large weight maintenance study (Pound of Prevention) conducted at the University of Minnesota. They observed, *"…regular self-weighing of at least weekly frequency was associated with lower BMI and greater weight losses over time in these two groups"* (Linde et al., 2005, p. 214). Although the frequency of self-weighing was associated with other healthy behaviors such as eating less fat, increasing exercise, and not smoking, when these variables were controlled in their statistical models, the effect of frequent self-weighing remained.

A similar result was reported by Van Wormer et al. (VanWormer et al., 2009) in a weight loss study that involved a home telemetering system that automatically transmitted the weight of the participant directly to the experimenters every time the participant weighed themselves. The frequency of self-weighing (number of days of self-weighing divided by the total number of days of treatment) was a significant predictor of the amount of weight lost during the 6 months of weight loss treatment. By the termination of treatment the percentage of participants who lost at least 5% of their weight was significantly higher in those who weighed themselves at least weekly (46%) than those who weighed themselves less than weekly (8%), a difference that disappeared one year later.

Also consistent with the studies that observed a statistically significant relationship between self-reported frequency of self-weighing and success at preventing weight gain is a recent study by Van Wormer et al. (VanWormer, Linde, Harnack, Stovitz, & Jeffery, 2012). They examined the effectiveness of Healthworks, a program designed to prevent weight gain in the workplace, on 1,747 employees associated with six worksites. The program consisted of multiple communications concerning health, diet, and exercise and the installation of a number of scales in the workplace. Feedback from the aggregate weight data was provided in monthly newsletters. At the end of two years, weight data and the reported frequency of weighing was aggregated and analyzed (Figure 1.4).

Figure 1.4



Change in weight as a function of the frequency of weighing for healthy weight, overweight and obese participants. From (VanWormer et al., 2012).

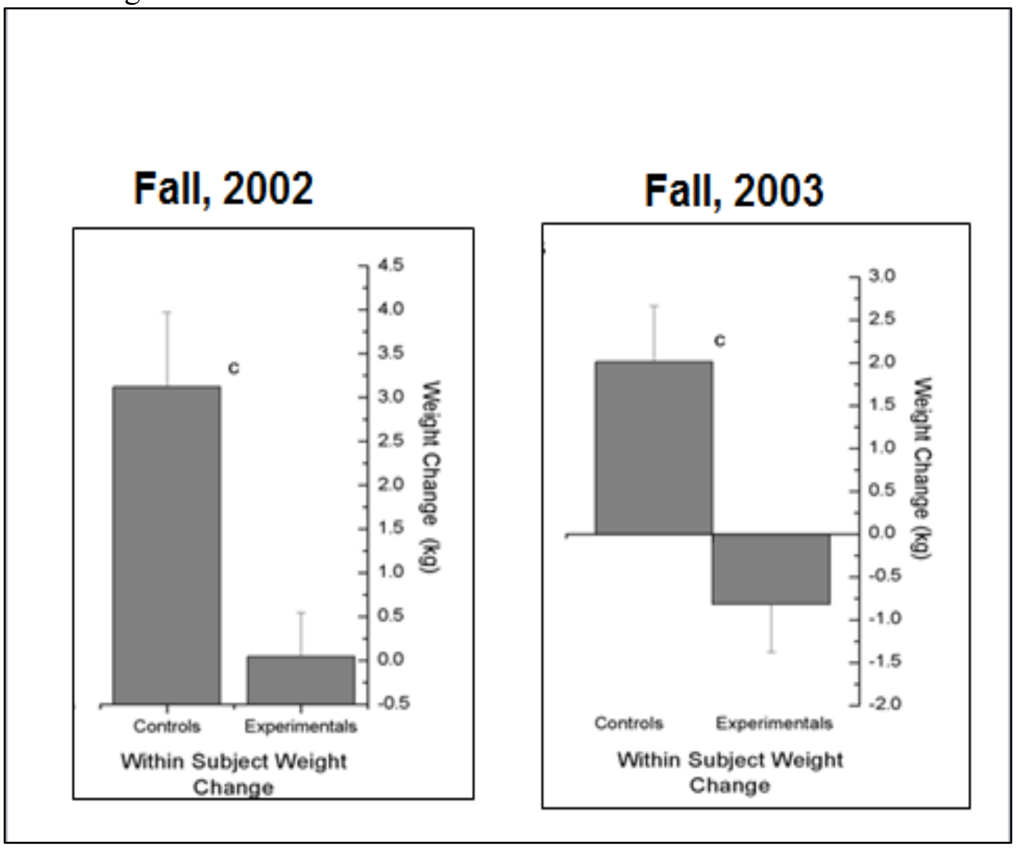
Not only did reported frequency of weighing correlate with the prevention of weight gain, but the greater the initial body weight, the greater the suppressing effect of reported self-weighing on weight gain. Despite the correlational design of the study, the results represent the first sign that an inexpensive, public health measure such as self-weighing may be effective in preventing weight gain in overweight and obese individuals.

Self-weighing and weight control: intervention studies

Although the studies demonstrating a significant relationship between reported frequency of self-weighing and success with weight maintenance were fairly consistent, all were correlational in nature. This makes it logically difficult to draw the causal inference that the act of self-weighing is responsible for the improved weight control. It is also valid to conclude that personal motivation prompted these individuals to control their weight as it is to conclude that frequent self-weighing enabled them to control their weight. One of the first attempts to test the effects of self-weighing as a means to prevent weight regain was performed by Wing et al. (Wing, Tate, Gorin, Raynor, & Fava, 2006). They conducted a randomized controlled trial, using participants that had already lost at least 10% of their body weight in the past two years (Wing et al., 2006). Participants were randomly assigned to one of three groups: a face-to-face intervention, an internet intervention, or a control group (which received quarterly newsletters). Both intervention groups were provided with a scale and instructed to monitor their weight and report back to the researchers on a weekly basis. In addition, the participants were rewarded for preventing weight regain, or instructed to resume weight loss behaviors if they regained more than a set amount. Those in each of the intervention groups who reported weighing themselves daily were significantly less likely to regain their weight than those who reported weighing less frequently after a year and a half of the trial (Wing et al., 2006). Unfortunately, because the groups who weighed themselves also received additional nutritional advice, it is impossible to attribute the success of this group solely to self-weighing.

One of the most direct experimental tests of using frequent self-weighing as a solitary method of preventing weight gain was reported by Levitsky and colleagues who studied the effectiveness of self-weighing in preventing the freshmen weight gain (Levitsky, Garay, Nausbaum, Neighbors, & Dellavalle, 2006). In two separate studies, conducted one year apart, freshmen females were randomized to a control or experimental group and tracked for the first 4 months of their undergraduate experience. Experimental participants were given scales and asked to weigh themselves and email their weight to the researchers daily. In return, the freshmen received a graph of their weight with a line indicating their starting weight (mean of the first seven days of measurement). The only instructions they were given was to try to keep their weight at or below their starting weight. A matched group of controls were measured at the beginning and end of the semester. The change in weight over the first semester can be seen in Figure 1.5.

Figure 1.5



Change in body weight of students given scales to weigh themselves daily and their controls in two experimental studies. From (Levitsky et al., 2006).

The experimental groups' weight change was not significantly different from zero, while the control group gained about 3 kg in the first study and about 2 kg in the second study (Levitsky et al., 2006).

In a subsequent experimental test, Gokee-LaRose, Gorin, and Wing (2009) randomized young adults into two groups, a behavioral self-regulation group or a standardized behavioral treatment group. Both groups underwent 10 group sessions of behavioral modification during which they lost about the same amount of weight. Following the weight loss sessions, one group was then asked to weigh themselves daily and use the weight information to make adjustments in their subsequent energy intake or expenditure behaviors while the other group was asked to weigh weekly but not focus on their weight. At the end of the 10 weeks of maintenance, participants in the daily weighing group continued to lose weight (-0.18 kg) while those in the weekly weighing group regained some weight (+0.37 kg) (Gokee-Larose, Gorin, & Wing, 2009). The results were not significant, possibly because the sample size was too small and/or the length of the maintenance period was insufficient. Interestingly, at the post intervention follow up (20 weeks) about 70% of the participants in the daily weighing group reported that they continued to weigh themselves daily, whereas only about 17% of those in the weekly weighing group continued the behavior post-intervention. This study supports the idea that although frequent self-weighing may not benefit weight loss, it may be a helpful tool for weight regain prevention.

Gow, Trace, & Mazzeo also examined the effectiveness of self-weighing to prevent weight gain in first year college students (Gow, Trace, & Mazzeo, 2010). Intervention effects were isolated by comparing an education group, an education and weight feedback group (where participants self-weighed weekly and emailed the Principal Investigator (PI) similar to the method used in Levitsky et al. 2006) and a strictly weight feedback group (weighed weekly and emailed the PI) during a 6 week intervention. A significant BMI change was found between the combined intervention (weight change = -0.12 ± 2.92 kg) and the other groups, but contrary to the findings of Levitsky et al. (Levitsky et al., 2006), there was no significant benefit of either the feedback (weight change = +1.20 ± 2.55) or internet education (weight change = +1.47± 3.22) alone as compared to the control group (weight change = +1.04 ±3.45).

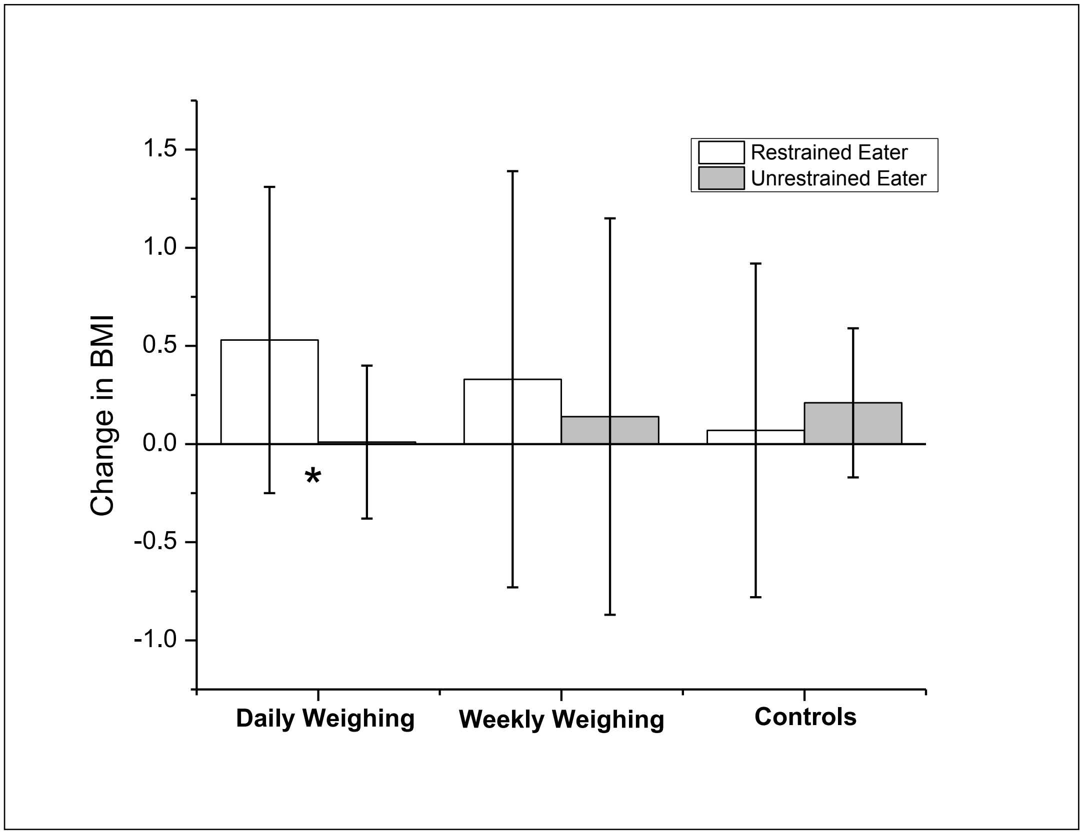
One possible reason there was no statistical significance difference between the feedback (self-weighting group) and the controls is that the study failed to observe a significant weight gain, perhaps because insufficient time (6 weeks) was allowed for the weight gain of the controls to occur.[2]

Strimas and Dionne (Strimas & Dionne, 2010) examined the effects of daily weighing on a group of freshmen during their first semester at college. They were particularly interested in examining possible negative effects of frequent self-weighing on restrained eaters. One of the authors had previously composed a warning of the dangers of self-weighing several years earlier (Dionne & Yeudall, 2005). Student volunteers from an introductory psychology course were randomly allocated to (a) daily weighing group, (b) a weekly weighing group, or (c) a control group asked to monitor their heart rate once a week. These three groups were further subdivided into an approximately equal number of restrained and unrestrained eaters using the Herman and Polivy Restraint Scale (Herman, Polivy, & Herman, 1980).

It is important to note that participants were not instructed to resist gaining weight or to maintain a record of their weight. The results of the effect of the various conditions on a change in BMI are shown graphically in Figure 1.6.

Figure 1.6

[2] Two unpublished doctoral theses also examined self-weighing using a similar method to Levitsky and colleagues but failed to find self-weighing significantly prevented weight gain among freshman (Butryn, 2006; Katterman, 2010). However, as in the Gow et al. study (Gow et al., 2010), both studies failed to find a significant weight gain in the control group.

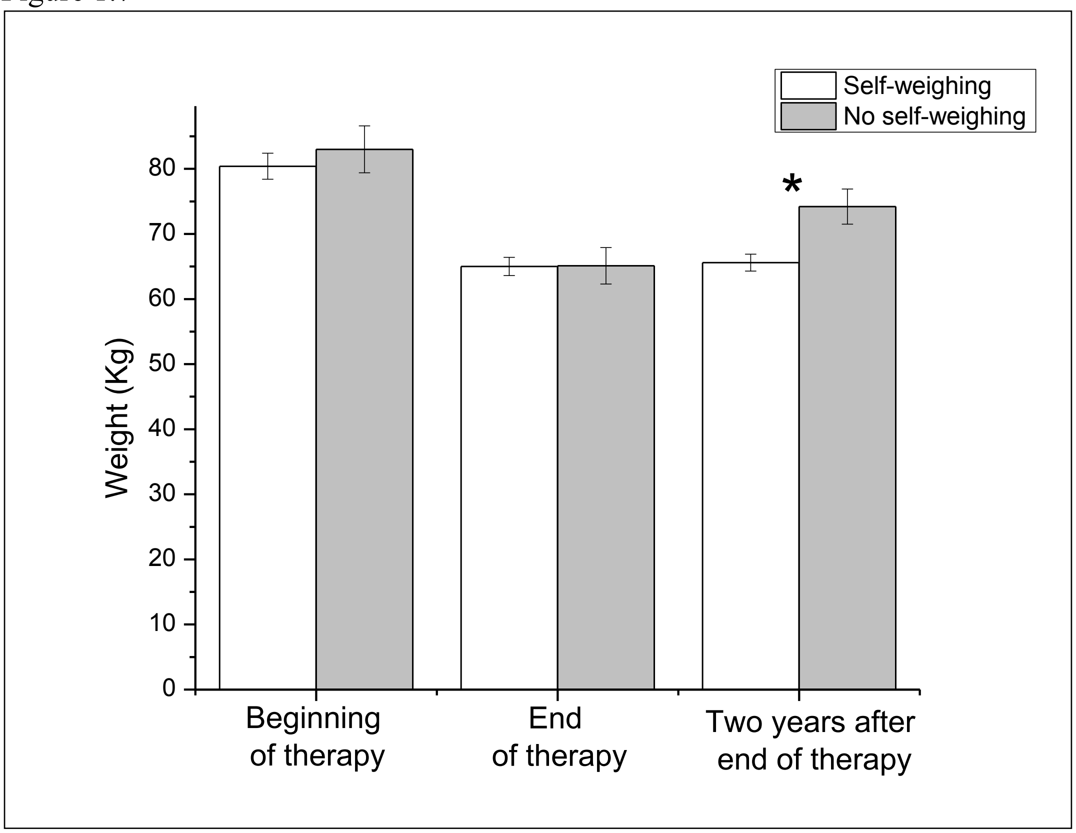


Weight change in restrained and unrestrained participants as a function of the frequency of self-weighing. * = <0.05. From (Strimas & Dionne, 2010).

No main effect of group, restraint or time (beginning versus end of the semester) was observed. The only subset of participants that demonstrated a statistically significant change in BMI over the semester was the restrained eaters in the group who were required to weigh themselves daily; they *gained* 0.53 BMI units. Although these results must be taken seriously because they may point out a danger of frequent self-weighing for particular segments of the population (see section below for further discussion), this was the first observation of this effect and it must be substantiated by other studies before accepted.

A clinical study of the use of multiple weigh-ins within a day to prevent weight regain was reported by Fujimoto et al., (Fujimoto et al., 1992). Like Stuart's original report (Stuart, 1967), Fujimoto et al. had one group of subjects weigh themselves four times each day: "*...immediately after waking, immediately after breakfast, immediately after dinner, and immediately before going to bed."*(Fujimoto et al,. 1992, p. 145-146). This group and a control group (no weighing) received 8 months of behavioral modification. Following the termination of behavioral therapy, the self-weighing group was asked to continue their multiple daily weigh-ins for two years. Body weight data of the females are presented in Figure 1.7.

Figure 1.7



Mean body weight of a group of patients who lost weight through behavioral modification therapy and followed up for 2 years. One group weighed themselves several times daily while the other group did not. * = $p < 0.05$. From (Fujimoto et al., 1992).

Final weight data could not be collected on the males. Frequent self-weighing did not facilitate weight loss during the treatment period in either males or females.

However, two years following the termination of therapy, the group who continued weighing themselves did not regain the lost body weight, whereas the non-weighing control group recovered about half of the body weight lost during therapy.

Recently, Steinberg and colleagues completed an intervention trial that yielded significant results: the intervention group lost an average of about 6.5% of their weight over a 6 month period which was significantly different from the controls' average percent weight loss (-0.35%)(Steinberg et al., 2013). The intervention entailed having participants weigh themselves daily using a Wi-Fi scale, receiving visual feedback of their weight over time, receiving weekly emails based on times weighing per week and weight loss progress, and emailed behavioral weight loss educational sessions. Like the experimental studies reviewed previously, however, it is not possible to determine the effect of self-weighing alone versus the effect of the email contact with participants or behavioral lessons.

Unlike the use of self-weighing as an adjunct to weight reduction, frequent self-weighing appears to be effective in the prevention of age-related weight gain or the prevention of weight regain after losing weight through dieting. Some evidence also suggests that self-weighing for preventing age-related weight gain may work for specific populations (unrestrained individuals). One limitation of this research that impedes acceptance of this conclusion is that in most studies where the effect of self-weighing is experimentally examined, the participants knew that their weight was being monitored. There is evidence showing that weight control is enhanced when people know they are being observed compared to when they think they are not being observed (Harvey-Berino et al., 2002; Tate, Wing, & Winett, 2001; Tate, Jackvony, &

Wing, 2003; Tate, Jackvony, & Wing, 2006). Therefore, it remains unclear how much of the effectiveness of frequent self-weighing is due to the act of self-weighing and how much is due the realization that someone else was watching their weight.

Potential hazards of frequent weighing

Despite the success of frequent self-weighing in the prevention of weight gain or regain, concerns have been raised about the safety of frequent self-weighing and the potential of causing eating disorders. The following section addresses these concerns.

Ogden & Whyman suggested an adverse consequence of frequent self-weighing in the published literature (Ogden & Whyman, 1997). They concluded from a small study of undergraduates that *"subjects who weighed themselves every day for 2 weeks reported deterioration in mood in terms of increases in both anxiety and depression"*(p.128). Fifteen years later, Mercurio and Rima reported that the *"high self-weighing group reported greater body dissatisfaction than the low self-weighing group"* (Mercurio & Rima, 2011, p.52). In Mercurio and Rima's study, the dependent variable examined was a measure of body dissatisfaction. However, an earlier study by Ogden and Evens (Ogden & Evans, 1996) also measured body dissatisfaction, but found no change in body dissatisfaction following two weeks of self-weighing. Similarly, in 2009 Welsh and colleagues failed to find any difference in the change in body dissatisfaction in a group of dieters who weighed themselves frequently compared to a group who weighed themselves less frequently (Welsh, Sherwood, VanWormer, Hotop, & Jeffery, 2009).

The "*deterioration in mood"* observed by Ogden and Whyman was not replicated in succeeding studies. Wing and colleagues (2007) measured frequency of self-weighing, depression (measured by the Beck Depression Inventory), binge eating episodes (Eating Disorder Questionnaire), and disinhibition (Eating Inventory) in a sample of participants involved in an eighteen-month prevention of weight regain study (Wing et al., 2007). They observed self-weighing to be associated with an increase in dietary restraint and a decrease in disinhibition and depressive symptoms. Of note, an increase in dietary restraint also has been associated with successful weight loss maintainers observed from the National Weight Control Registry (Klem, Wing, McGuire, Seagle, & Hill, 1998).

A similar lack of *"deterioration in mood"* was also reported by Gokee-Larose, Gorin, and Wing in a weight loss study of young adults (Gokee-Larose et al., 2009). They analyzed changes in body image (Body Shape Questionnaire), binge eating behavior, depressive symptoms (Beck Depression Inventory), and subscales of an eating disorder questionnaire (Eating Disorder Examination-Self-Report Questionnaire) in a group of young adults who were asked to weigh themselves daily during a 10-week period of weight maintenance following weight loss. All of these psychological measures improved with treatment and rate of improvement was not different in a group of controls who did not weigh themselves. The authors concluded, *"Daily weighing was not associated with any adverse changes in psychological symptoms"* (Gokee-Larose et al., 2009, abstract 'results' section).

A different approach to assess the potential harm of frequent self-weighing was reported by Quick and colleagues (Quick, Larson, Eisenberg, Hannan, & Neumark-Sztainer, 2012). They analyzed the results of a written survey sent to 2,287 young adults intended to measure their health behaviors. They observed that 18% of women and 12% of men weighed themselves at least “a few times a week.” They observed significant correlations between self-weighing and unhealthy weight-control practices. Unhealthy weight control practices were defined as responding affirmatively to having engaged in *“any of the following behaviors to lose weight or keep from gaining weight in the past year: “‘fasted,’ ‘ate very little food,’ ‘used food substitutes,’ ‘skipped meals,’ ‘smoked cigarettes.’”* (p 470). Some of these measures, such as *‘used food substitutes’* or *‘skipped meals,’* may not necessarily be considered “unhealthy” if the participants were trying to lose weight and weight loss was medically advisable. Moreover, these authors also reported that *“positive associations between more frequent self-weighing and healthy WCBs* [weight control behaviors] *were also found.*(p 471)*”*

Quick and colleagues concluded that “*young adults who monitored their weight a few times per week or more reported significantly more depressive symptoms (in women) and poorer body satisfaction (in men) compared with young adults who monitored their weight less often.*(p 472)*”* While these results appear to contradict previously discussed studies (Gokee-Larose et al., 2009; Wing et al., 2007) and support the original warning by Ogden and Whyman (Ogden & Whyman, 1997), it must be pointed out that the results of Quick and colleagues’ study were correlational (Quick et al., 2012). It is plausible that depressed females or males with poor body satisfaction chose to weigh themselves more frequently than non-depressed, body-satisfied females or males as it is that frequent self-weighing causes depression or poor body satisfaction.

One mediating factor between self-weighing frequency and the behaviors addressed by Quick et al. (2012) may be feelings about one's shape and weight. Klos, Esser, & Kessler (2012) surveyed undergraduate students to investigate the relationship between frequency of self-weighing and several different dimensions of body image using the Multidimensional Body-Self Relations Questionnaire (MBSRQ) and the Eating Disorder Examination-Questionnaire (EDE-Q). After controlling for body mass index, self-weighing frequency was positively associated with the following dimensions of the MBSRQ in men: Health Orientation (adjusted $r^2 = 0.37$; $p < 0.01$), Health Evaluation (adjusted $r^2 = 0.26$; $p < 0.05$), Fitness Orientation (adjusted $r^2 = 0.23$; $p < 0.05$), and Body Areas Satisfaction (adjusted $r^2 = 0.24$; $p < 0.05$). There were no significant associations between dimensions of the EDE-Q and self-weighing frequency. However, in women, a significant correlation was found between self-weighing frequency and Appearance Orientation (adjusted $r^2 = 0.16$; $p < 0.05$), Fitness Evaluation (adjusted $r^2 = 0.18$; $p < 0.05$), Overweight Preoccupation (adjusted $r^2 = 0.31$; $p < 0.001$) and Shape Concern (adjusted $r^2 = 0.20$; $p < 0.01$). As with the Quick et al. (2012) study it is not possible to determine whether these perceptions about one's body lead to frequent weighing or vice-versa. Though they provide useful information, these studies do not provide evidence to support or refute the safety of self-weighing in healthy young adult populations.

Finally, studies that deceive people of knowing their true weight have been used to provide evidence that frequent self-weighing may be harmful. Ogden and Evans (1996) randomly allocated participants into fictional height and weight categories: overweight, normal weight or underweight. They found higher measures of depression among those who had been told that they were in the overweight category than those assigned to normal or underweight categories. Anxiety was not affected. McFarlane, Herman and Polivy (1998) replicated this finding by demonstrating that weighing people on a scale that indicated they weighed five pounds heavier than they actually weighed, increased measures of depression in restrained, but not unrestrained individuals. More recently, Winstanley and Dives (2005) also showed that by deceiving people by having them weigh themselves on a bogus scale that displayed their weight to be 7 pounds above their true weight increased measures of anxiety and depression in all participants compared to those that weighed themselves using an accurate scale. Despite the consistency of the results, it is problematic to compare studies where participants were deceived by "rigged" scales to those where participants were using authentic scales. False weight information may be perceived as depressing to anyone interested in maintaining a healthy weight or preventing weight gain.

Thus, although there are hints from the literature that frequent self-weighing may be harmful to certain individuals, there is no behavioral or psychological parameter that consistently reflects harm caused by frequent self-weighing. The evidence, however, is stronger in adolescents showing that frequent weighing may be associated with harmful behaviors (Quick et al., 2012; Quick, Loth, Maclehose, Linde, & Neumark-Sztainer, 2013).

Potential mechanisms through which frequent self-weighing may prevent weight gain or regain

Frequent self-weighing may enhance weight control through at least three mechanisms. First, information - viewing a graph of body weight over time provides feedback indicating individuals' current status of energy balance. Although there is considerable daily variation in measured weight due to changes in body water, body glycogen content, and the contents of the gastrointestinal tract, graphing repeated measures of weight reveals a pattern of change indicating a change in body tissue. This information can then be used to estimate the amount of food that should be consumed or the amount of physical energy that should be exerted during the day in order to maintain body weight at a certain level. From studies of internet weight control programs, it has been found that providing frequent feedback to participants is one of most powerful predictors of the efficacy of the program (Haapala, Barengo, Biggs, Surakka, & Manninen, 2009; Krukowski, Harvey-Berino, Bursac, Ashikaga, & West, 2012; Turk et al., 2012)

The second mechanism through which frequent weighing may affect energy intake and expenditure behaviors is that the scale may act as a source of negative or positive reinforcement. Noting an increase in morning body weight may negatively reinforce behaviors that may have led to the increase in weight, such as having lunch in a restaurant. Alternatively, observing a loss in morning body weight may positively reinforce the consumption of a small meal replacement, or skipping dessert, behaviors that might have occurred during the previous day.

Third, stepping on the scale may act as a priming stimulus that sensitizes the individual to stimuli in the environment which may cause eating. For example, there is evidence that participants will eat less when in the presence of a bathroom scale (Brunner, 2010). The memory of the scale along with the informational display on the graph may affect the individuals' vulnerability to environmental cues associated with eating. More research about the use of frequent weighing is necessary, not only to determine its effectiveness in preventing weight gain or regain, but also to identify the processes through which it affects behavior in order to maximize its effect.

Conclusion

This review extends the conclusions reached in an earlier review by Van Wormer and colleagues (Vanwormer et al., 2008) that frequent self-weighing appears to be a useful tool for successful weight management. This review suggests that frequent self-weighing as a method to control body weight may not be effective to aid weight loss. On the other hand, published data appear to strongly suggest that people who weigh themselves frequently lose more weight and can maintain their reduced weight longer than people who do not weigh themselves frequently. Such data may mean that the frequency of weighing may be an indicator of the motivation to lose and/or sustain a weight loss. However, several experimental studies have demonstrated that the use of self-weighing may be an effective technique to prevent individuals from age-related weight gain. Although we must be vigilant of possible negative side-effects of frequent self-weighing on restrained eaters and people that might be vulnerable to eating disorders, the data, so far, does not present a consistent argument for frequent self-weighing as a serious risk. Like other medical treatments, some groups with other conditions or co-morbidities will benefit more from other types of interventions. This review of the literature suggests that frequent self-weighing may be an effective tool to help individuals manage weight.

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CHAPTER 2

DAILY WEB-BASED WEIGHT MONITORING FOR WEIGHT REDUCTION IN OBESE AND OVERWEIGHT ADULTS

Introduction

Several studies have included self-weighing as a component of a behavioral weight loss intervention (Fujimoto et al., 1992; Gokee-Larose, Gorin, & Wing, 2009; Heckerman, Brownell, & Westlake, 1978; Mahoney, 1974; Mahoney, Moura, & Wade, 1973; Romanczyk, Tracey, Wilson, & Thorpe, 1973; Romanczyk, 1974; Steinberg et al., 2013; Stuart, 1996). Because self-weighing has been used with other techniques to promote weight loss, it has not been possible to assess the effectiveness of self-weighing by itself as a technique to promote weight loss. In the few studies that compare groups that only differ in self-weighing frequency, results indicate that the behavior is not helpful for weight loss (Heckerman et al., 1978; Mahoney, 1974; Mahoney et al., 1973; Romanczyk et al., 1973; Romanczyk, 1974). However, since these studies were conducted, evidence has been accumulating suggesting that frequent self-weighing may be beneficial in weight loss or the prevention of weight gain or weight regain in adults (Butryn, Phelan, Hill, & Wing, 2007; Fujimoto et al., 1992; Gokee-Larose et al., 2009; Jeffery & French, 1997; Jeffery & French, 1999; Klem, Wing, McGuire, Seagle, & Hill, 1997; Linde, Jeffery, French, Pronk, & Boyle, 2005; Steinberg et al., 2013; Wing, Tate, Gorin, Raynor, & Fava, 2006). This evidence, with the exception of Fujimoto et al. (1992) and Steinberg et al. (2013) (to be discussed later), is correlational making it inappropriate to make a causal inference about the role of self-weighing in weight control.

Isolating the effects of frequent self-weighing for weight loss in adults is important for the public, healthcare practitioners and researchers. Despite evidence that increases in overweight and obesity may be decreasing in some categories of the population, the proportion of adults in the United States that are overweight or obese remains high (Flegal, Carroll, Kit, & Ogden, 2012). A weight loss as small as 5% of body weight may improve health (Blackburn, 1995). Because frequent self-weighing is both relatively affordable and not time consuming, it is important to test it as an independent method to produce sustained weight reduction.

This study tests the effectiveness of a simple and affordable behavioral technique, frequent self-weighing and visual feedback, for weight loss in adults.

Methods

Conceptual development of the intervention

The Caloric Titration Method (CTM) provides daily feedback of an individual's weight trends over time. This internet-based program graphically displays the history of an individual's weight online. The image below represents what a user can see of their weight after an individual has been using the CTM for a while.

Figure 2.1

Sample view of CTM weight graph

The graph shows the example user's weight in pounds plotted by time (date). Once a user begins using the program and enters a sufficient number of weights, a green line appears 1% below their current weight to show the users' current target weight. The green line encourages steady, incremental weight loss of 1% of body weight at a time. Once achieved, the user is directed to maintain this weight loss to ensure that the changes made are sustainable. The percent decrease (in 1% increments) and holding continues until a maximum of 10% loss is reached, when maintenance is recommended. Intervention participants were directed to aim for the 10% weight loss goal in a years' time, at which time they would maintain this loss.

A key concept in the philosophy of the CTM is a slow rate of weight loss. Participants are directed to make the kind of lifestyle changes that produce a 1% decrement in weight, but feel sufficiently comfortable to permanently sustain those changes. This slow weight loss emphasis is in direct contrast with what others have proposed to yield successful maintenance based on weight loss literature (Astrup & Rossner, 2000).

With this information provided to the user daily, he/she can make adjustments (titrate) to their intake or expenditure in order to control their body weight. Moreover, the information provided by the weight chart is assumed to reinforce behaviors which cause the weight to move in the intended direction. This system allows participants to make changes in their eating or activity that best fit their lifestyle. This kind of flexible restraint has been found to be more closely related to successful dieting that the more conventional type of dieting (Elfhag & Rossner, 2005).

Participants & Procedure

One hundred and seventy eight individuals responded to newspaper advertisements, email newsletters, and a public service announcement on a local radio. Advertisements for the study indicated that anyone interested in losing weight who was over the age of 18 who was not pregnant or planning to become pregnant, not diabetic, and did not have a history of an eating disorder, and had a Body Mass Index (BMI) of greater than 27.0 kg/m^2 should contact the principal investigator via email.

Of the 178, sixteen who were interested in participating did not meet the BMI cutoff. These individuals were invited to participate in another study arm, a 'weight maintenance' cohort and this study is discussed in another chapter (CHAPTER 4).

Individuals who indicated their interest in the study and who met the inclusion criteria were randomized to one of two groups. Based on this initial randomization, they were offered to attend one of two sessions, held on different days (to maximize attendance). A record was kept of the date the participants signed up for, and those who did not attend the initial session were contacted and offered a day and time for a makeup small group session. The sessions were recorded so that the same information would be communicated to those who missed the large group session. Participants were offered a maximum of three additional meetings. If they were nonresponsive or did not attend the follow up meetings, they were classified as no shows. One participant lost contact and was not followed up with or randomized to a group. Of the 162 participants who were randomized to the experimental or control group (88 and 74 participants respectively), 8 never attended an initial session and 4 participants contacted the PI after being randomized to say that they did not meet some of the inclusion criteria after all (e.g. had diabetes and did not notice that was an exclusion criteria; left initial session because was diabetic). Participants were not informed of their group assignment until the initial session to minimize control group dropout: Chi-squared statistics did not reveal significant differences in which group the no shows were randomized. The control participants were told they would receive the treatment that the experimental participants received after one year.

All participants were invited to an initial session in November of 2010 presented by David Levitsky, which was recorded for those who did not/could not attend. Levitsky talked about evidence based strategies for weight loss during this session. The only difference between control and experimental group initial sessions were that in the experimental group session, all participants were provided with a typical bathroom scale (American Weight Scales Model 330 LPW) that they were asked to use daily under consistent circumstances and shown how to access a computer website (http://weightloss.human.cornell.edu/) where they were directed to register and then enter their weight daily. They were provided with an informational handout (see Appendix 2.1). After entering their weight, the computer program displayed a history of the participants' weights. After the first 8 days of entries, a green line representing the mean body weight for those eight entries and was displayed on the weight chart. The subjects were asked to try to maintain their weight at the green line. Multiple initial reschedule sessions were planned to optimize the possibility of participation. Only one interested and eligible participant did not attend an initial session.

Participants were weighed by the researchers at the initial session (time point1), 6 months after the initial session (time point 2), 12 months after the initial session (time point 3), and 24 months after the initial session (time point 5). Weigh-ins were conducted in campus buildings or in a public location of the participant's choosing.

Online questionnaires were disseminated at each of the time points listed above, with the addition of a questionnaire 18 months after the initial session (time point 4). The questionnaires assessed psychological factors and their relationship to weight change and the CTM and are discussed elsewhere (CHAPTER 3).

After one year, participants randomized to the control group were given access to the experimental intervention – they were provided with a body weight scale, the same informational handout (Appendix 2.1), and information about how to set up an account using the CTM website. Participants in the experimental group continued weighing themselves and entering their weight during year 2 of the trial.

This chapter presents 1) tests of differences in weight of participants in the control and experimental group over the first year, 2) evaluates the second year for maintenance of weight in the experimental group (2^{nd} year using the treatment) and 3) examines the effectiveness of the CTM in the delayed treatment control (2^{nd} year = 1^{st} year of treatment).

Results

Participant characteristics

The entire sample had an average age of 46.6 ± 9.8 years, an average Body Mass Index (BMI) of 33.5 ± 5.1 kg/m^2, and had completed an average of 15.9 ± 2.2

years of education (range 12 – 19 years). The percentage of females in the study was 81.9 (n = 122); the percentage of males was 18.1 (n = 27).

Most participants self-identified as white. The breakdown of ethnicities was: 144 or 88.9% of participants self-identified as white, 6 participants or 3.7% of the sample self-identified as African American, 3 participants or 1.9% of the sample self-identified as American Indian, 2 participants or 1.2% of the sample self-identified as Asian, 1 participant or 0.6% of the sample self-identified as Hispanic, and 2 participants or 1.2% of the sample self-identified as "other" and filled in "Azores Portuguese" or "Jewish".

Characteristics by treatment group can be found in Appendix 2.2 for these and other baseline study characteristics.

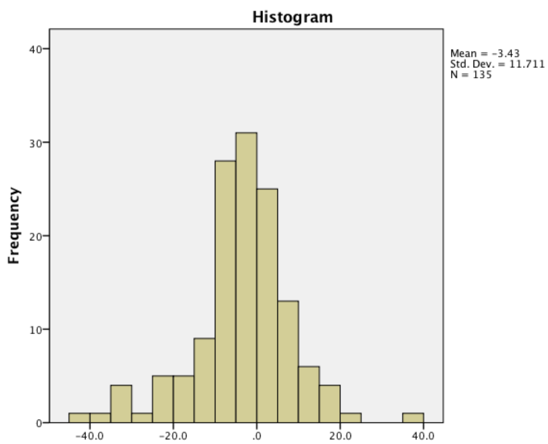
Year 1 Results

Primary outcome: change in body weight

The dependent variable of change in body weight was analyzed in several ways. Descriptive statistics and basic t-tests were performed and then mixed models were used to analyze the data more extensively. All analyses follow an intent to treat strategy.

Change in body weight over the first year of the study was calculated by subtracting measured weight at baseline from measured weight at the 12-month check-in point for participants that attended both measurement time points. Based on the frequency histogram this variable appeared to be normally distributed; however if strictly adhering to the statistical test of normality, the Shapiro-Wilk statistic was 0.955 with a p-value of 0.000, which would instruct rejecting the null hypothesis that the sample is from a normally distributed population. The sample mean is -3.43 meaning that on average, each person in our sample lost 3.43 pounds over the first year of the study. This sample consists of 135 people and has a sample standard deviation of 11.7 pounds. This value is significantly different from zero ($p < 0.001$; 2-tailed t-test).

Figure 2.2



Change in body weight

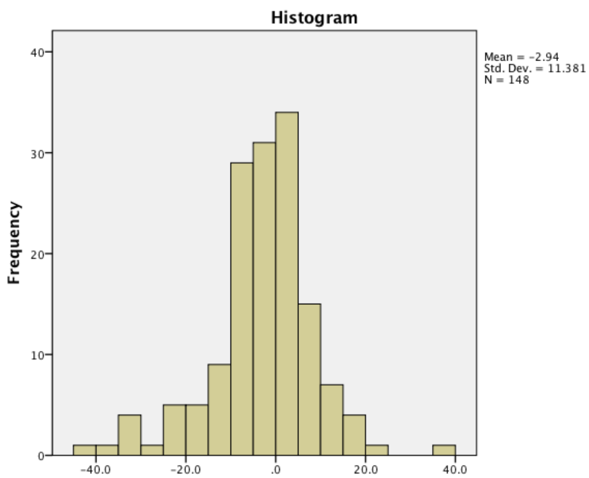
Histogram of change in body weight (lbs)

Missing Data

Due to participants not attending weigh-in sessions and ignoring contact with the PI to conduct a weigh-in, some participants only have weights at baseline and 6 months. In addition, a small number of participants filled out the survey and/or attended the initial session and initial weigh-in and then realized that they were not eligible for the study and were designated as a discontinued contact. Because these individuals were randomized to a group and officially registered and confirmed participation, any information (e.g. survey or first weight) is included when possible.

These individuals do not have a value for the change in weight over the first year. In the cases where the individual came to the initial session only, then their initial session weight is carried forward, giving them a weight change over the first year of “0”. These variables are indicated by the acronym “LOCF” (Last observation carried forward). All tests are repeated below using both the (a) original variable that excludes people with missing 12 month weights and the (b) LOCF variable that includes them. The histogram of the variable weight change over the first year with LOCF appears below:

Figure 2.3



Change in body weight with LOCF

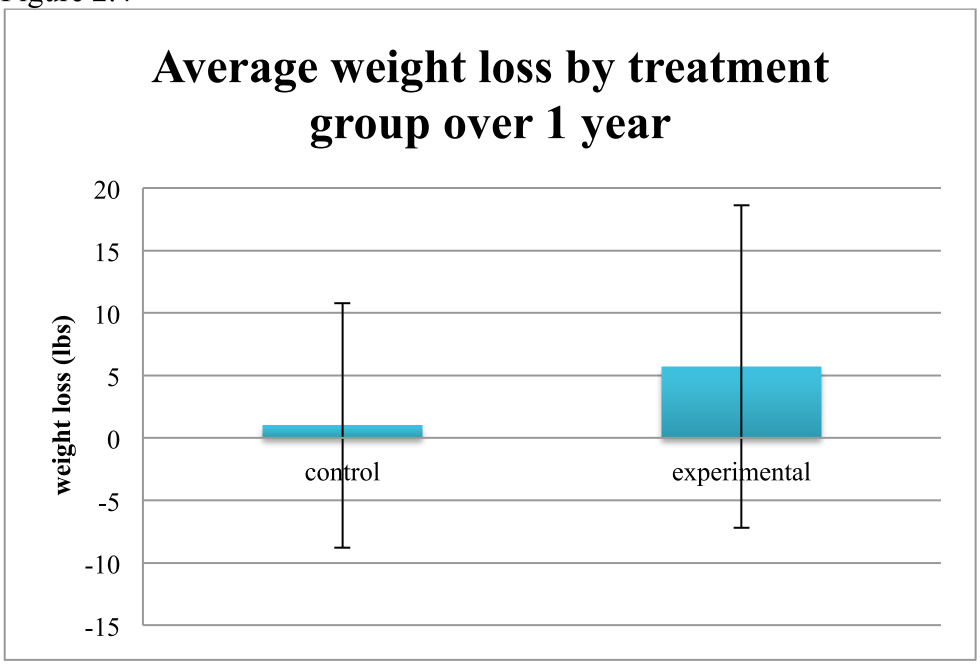
Histogram of change in body weight (lbs) with last observation carried forward

T-tests

All t-tests were 2-tailed because it was reasoned a priori that the results could go in either direction (the control group could lose more weight than the experimental group or the experimental group could lose more weight than the control group).

Excluding those with missing data: [dependent variable = wt3minuswt1 = change in weight over the first year of the study] using an independent samples t-test, a significant difference was found between the control group (n=65; mean within subject weight loss of 1.0 ± 9.8 pounds), and the experimental group (n=70; mean within subject weight loss of 5.7 ± 12.9 pounds) over the first year (p for difference = 0.019). This is displayed in the following bar graph:

Figure 2.4



Average weight loss (lbs) by treatment group over the first year of the study. Error bars are +/- 1 standard deviation.

Though change in weight appeared to be normally distributed, we followed this test with nonparametric tests to examine whether this affected the significance of the result. Nonparametric tests (Mann Whitney U) revealed very similar results (p for difference = 0.02). Of note, the p-value of the parametric t-test would be exactly the same as the nonparametric test (0.02) if equal variances were assumed. Since the p-value of Levene's Test for Equality of Variances was 0.04, the assumption that the variances were equal was rejected and equal variances were not assumed, producing a p-value of 0.019 as previously reported.

Including those with missing data: [dependent variable = wt3LOCFminuswt1LOCF = change in weight over the first year of the study LOCF] Using an independent samples t-test, a significant difference was found between the control group (n=67; mean within subject weight loss of 0.8 ± 9.8 pounds), and the experimental group (n=81; mean within subject weight loss of 4.7 ± 12.3 pounds) over the first year (p for difference = 0.037).

Mixed Models

Using a t-test to analyze these data has several shortcomings. With a t-test, one is not able to control for covariates, which may significantly explain much of variability in the response. The t-test uses each person's weight change as the dependent variable, calculating this based on subtraction. These difference values are averaged by group and compared. The difference variable may not accurately describe weight change. There are multiple ways of getting from point 'A' to point 'B' including loss then regain, gain then extreme loss, etc. A modeling strategy that takes the midpoint (6 month time point) into consideration is a mixed model. Instead of calculating a difference score by subtracting one point from another (in this case baseline measurement is subtracted from 12 month check-in measurement), the mixed model allows for an individual regression line to be calculated through the three weight measurements for each individual. Mixed models also allow for maximal usage of missing data; if an individual only has 2 data points for the first year, they can still be used. For comparison a random intercept random slope mixed model was used; this allows for each individual to have their own intercept and slope of the three (or two) weight data points, allowing for more accurate description of their weight trajectory. This is important with this type of study because we are interested in how weight trajectory changes over the first year based on treatment group.

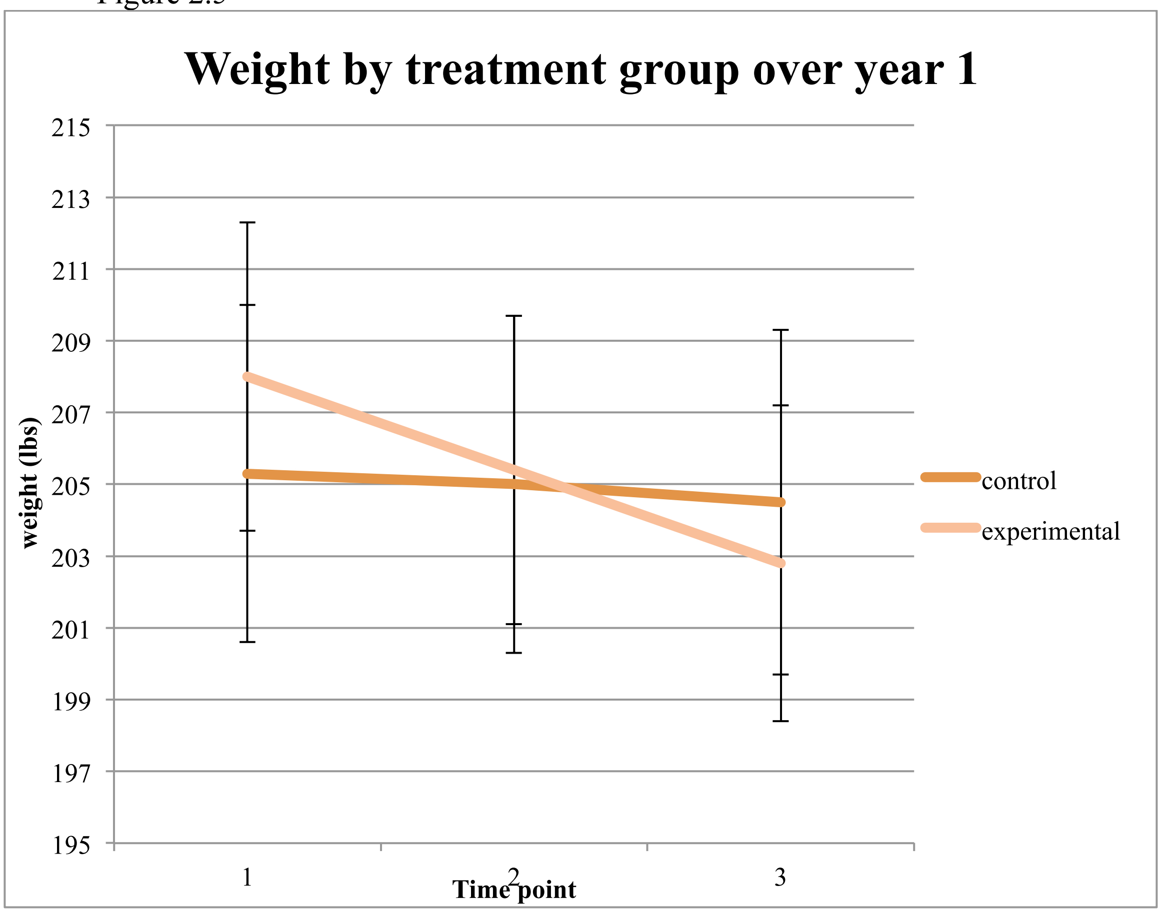
The basic mixed model to address the a priori hypothesis of this study includes a main effect of treatment group, a main effect of time, and the interaction between time and treatment group. The interaction term answers the question if weight changes differently by treatment group. Main effects are not interpreted, as this would not be appropriate given the inclusion of the interaction in the model. The syntax and results are in Appendix 2.3.

Time was analyzed as a continuous variable. Theoretically, considering time as a continuous variable is justifiable as time represents discrete points that are the same distance apart (6 months in this case). In addition, a random slope is able to be included when time is continuous but not when time is categorical. Empirically, considering time as a categorical variable estimates a different change in weight between time points 1 and 2 and 2 and 3, whereas considering time as a continuous variable averages these and assumes a constant change in weight over the course of the time points. Parameter estimates of the slope are estimated by using time point as continuous average (about 4) compared to the categorical estimations (about 3 and 5).

The Type III Tests of Fixed Effects table shows that the interaction between treatment group and time is significant ($p = 0.026$). Next, in the Estimates of Fixed Effects table, the reference group is when randcode = 2. This stands for the treatment or experimental group. When going from the linear regression calculated from the mean linear regression of all of the participants' weight trajectories over one year in the experimental group, to the linear regression calculated from the mean of all of the participants' weight trajectories over one year in the control group, the slope of that line increases by 2.18 pounds. The 95% confidence interval for this estimate is 0.26 – 4.10; since the confidence interval does not encompass zero, this effect is significant.

A visual may be useful to help interpret these estimates:

Figure 2.5



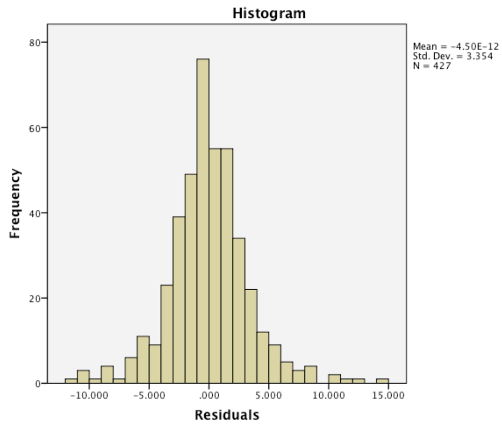
Body weight (lbs) over the first year of the study by treatment group using a mixed model for parameter estimates at each time point. There are 6 months between time points. Error bars are +/- 1 standard error.

The line graph replicates was found using simple t-tests: at 6 months (time point 2) the difference between groups trended toward significance but had not reached significance (p values ~ 0.20), and at 12 months (time point 3) this difference was apparent (significant at $p < 0.05$). The estimated marginal means, or estimates of average body weight by group and time point, at time point 1, 2, and 3 for the control group are as follows: 205.3 ± 4.7 pounds, 205.0 ± 4.7 pounds, and 204.5 ± 4.8 pounds, respectively. The estimated marginal means at time point 1, 2 and 3 for the experimental group are as follows: 208.0 ± 4.3 pounds, 205.4 ± 4.3 pounds, and 202.8 ± 4.4 pounds, respectively.

Outliers

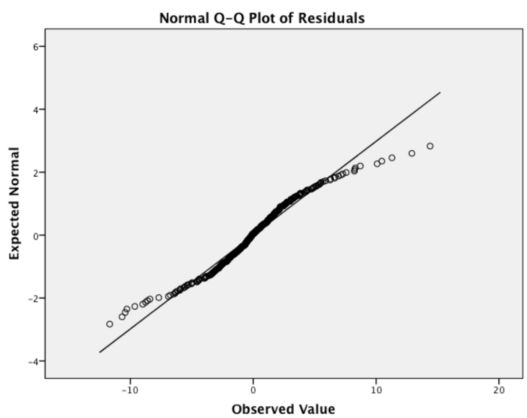
For analyses based on regression (mixed model), residuals should be normally distributed. Below is a histogram of the residuals, a normal Q-Q plot of the residuals and a graph displaying residuals versus predicted values for the dependent variable body weight. Again, if strictly adhering to the statistical test of normality, the Shapiro-Wilk statistic was 0.965 with a p-value of 0.000, which would instruct rejecting the null hypothesis that the residuals are normally distributed. The skewness statistic for the residuals is 0.174 and the standard error of skewness is 0.118. This indicates that the distribution is slightly skewed to the right, as the value is positive. The skewness statistic is not more than twice its standard error (in this case $0.118*2 = 0.236 > 0.174$), which does not signify a departure from symmetry. The kurtosis statistic, which measures how much of the data is clustered around the mean as compared to in the tails of the distribution, is 2.329, meaning most observations fall near the mean and the tails of the distribution are thin (few data points). From the graph of the residuals versus predicted values, it appears that the residuals are similarly distributed about the horizontal axis (balanced number of positive and negative).

Figure 2.6



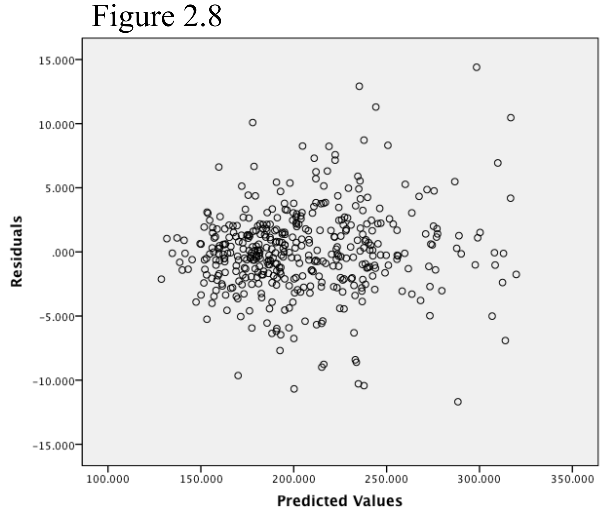
Histogram of the residuals of body weight (lbs)

Figure 2.7



Expected versus observed values of the residuals of body weight (lbs)

Figure 2.8



Residuals of body weight (lbs) versus predicted values of body weight (lbs)

Outliers, or extreme data points, may be defined/handled in a variety of ways. Considering any data point that has an associated residual greater than or less than 3 standard deviations (3.354 * 3 = 10.062) from the mean of the residuals is how outliers are defined for this study. As shown in the histogram above, the mean of the residuals is -4.5E-12 or approximately 0.0000 the standard deviation is 3.354, meaning that the range of acceptable residual values falls between – 10.062 and 10.062. Using this criterion, the following participant IDs (PPTIDS) at the following time points are considered outliers:

Table 2.1. Outliers according to time point

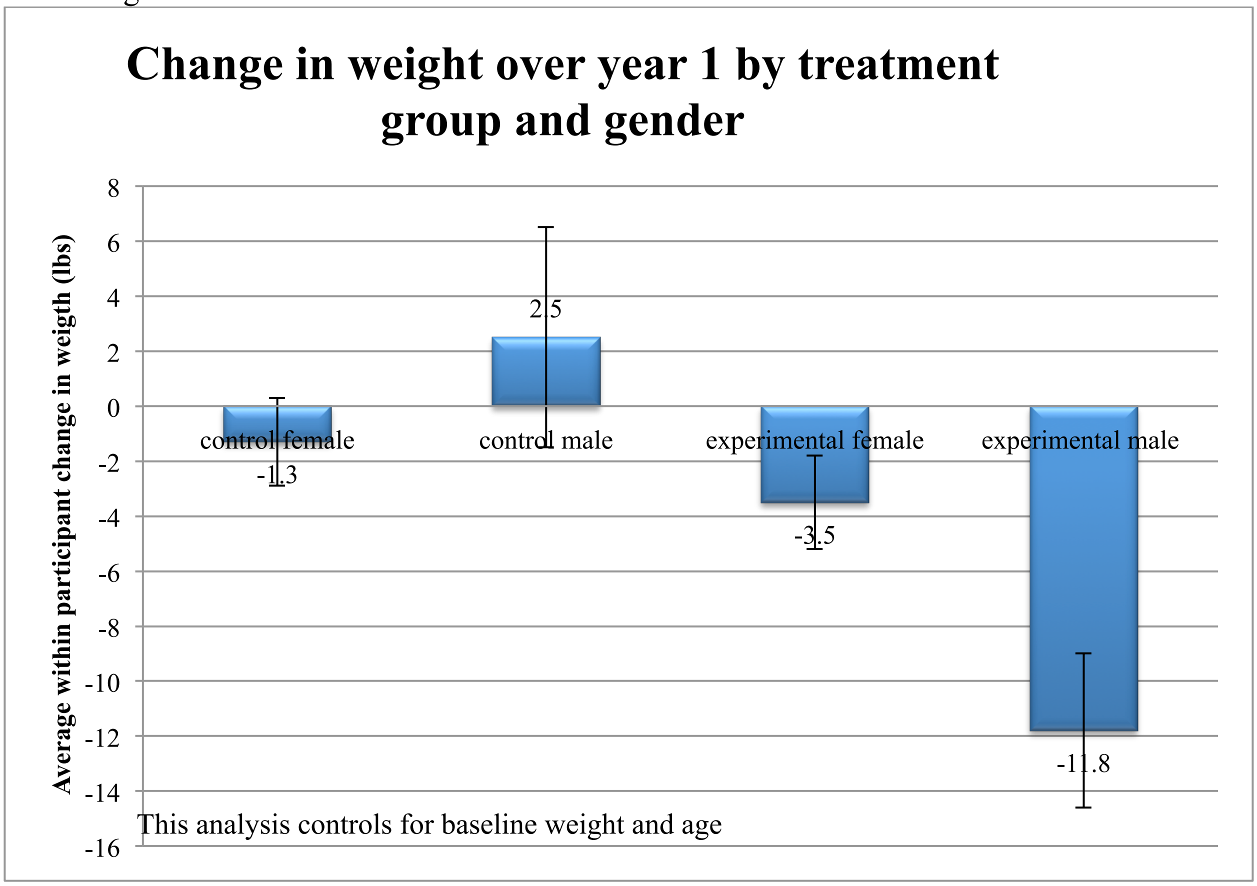
PPTID	Time point
18	1
18	2
52	2
52	3
95	1
100	2
105	2
108	2
144	3

When re-running the mixed model excluding these 9 ‘outliers’, the interaction of interest (treatment group*time point) remains significant at $p < 0.05$. This argument combined with the previously displayed graphs of the residuals indicates that including these data points, our data's residuals meet the assumptions to conduct linear regression modeling.

Exploratory analyses: Gender Comparisons

Further exploratory analyses revealed that gender was influencing the difference in weight over the first year. Two bar chart graphs are presented; the first controls for baseline weight and age (both NS, $p > 0.05$). There was an interaction between gender (male or female) and group assignment (control or experimental) that was significant at $p = 0.021$. The main effect of group assignment was significant at the $p = 0.002$ level, whereas the main effect of gender was not significant ($p = 0.453$). Note, it is not appropriate to interpret these main effects as main effects since they are involved in an interaction; they are merely described for thoroughness. The bars represent mean weight change in pounds, controlling for baseline weight and age, and the error bars are standard errors.

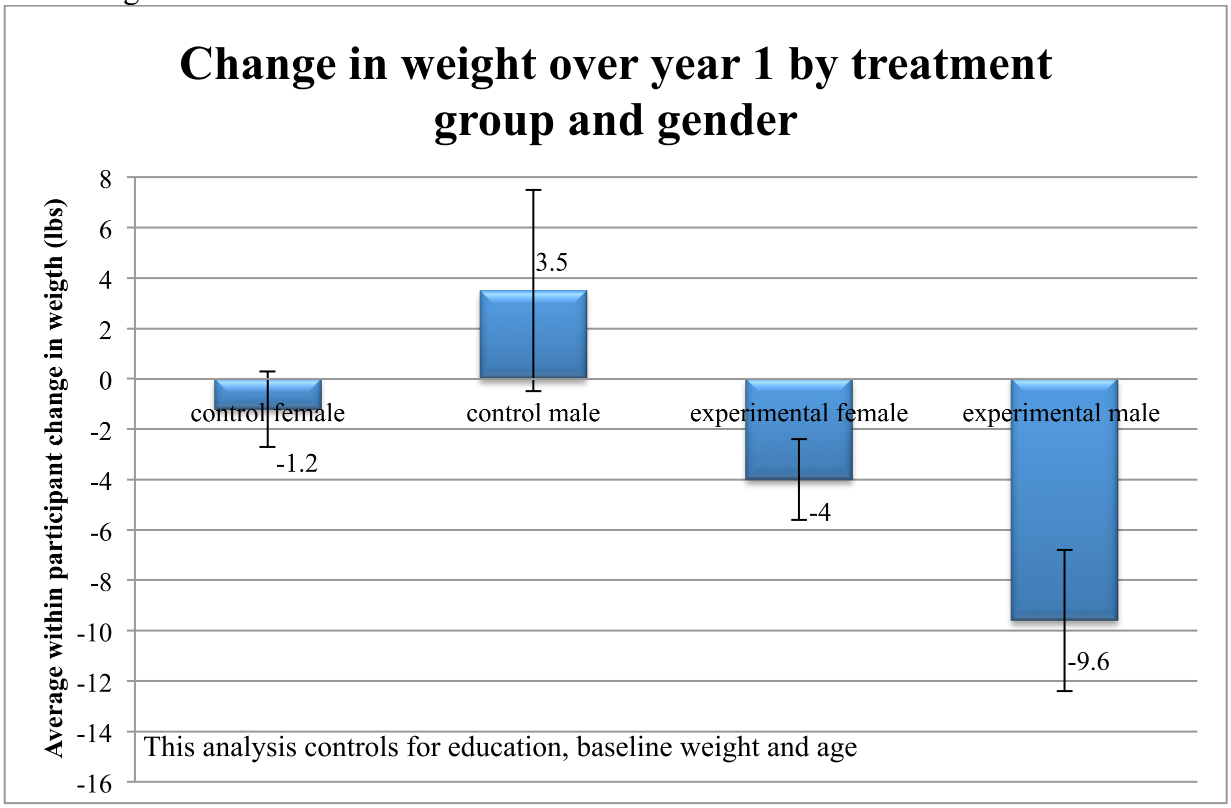
Figure 2.9



Change in weight (lbs) over the first year of the study by treatment group and gender, controlling for baseline weight and age. Error bars are +/- 1 standard error.

The next bar chart also controls for education in addition to baseline weight and age. Education is a significant covariate ($p = 0.027$). Age and baseline weight remain non significant.

Figure 2.10



Change in weight (lbs) over the first year of the study by treatment group and gender, controlling for education, baseline weight and age. Error bars are +/- 1 standard error.

Although the main effect of gender was not statistically significant (p = 0.453) the interaction was (p= 0.044). Further analysis indicated the main effect of group was significant for men (p = 0.01), not for women (p = 0.20). Due to the possibility that outliers were driving this effect, residual versus predicted values of the dependent variable, weight change over the first year, were plotted. The residuals appeared fairly evenly dispersed around the horizontal axis.

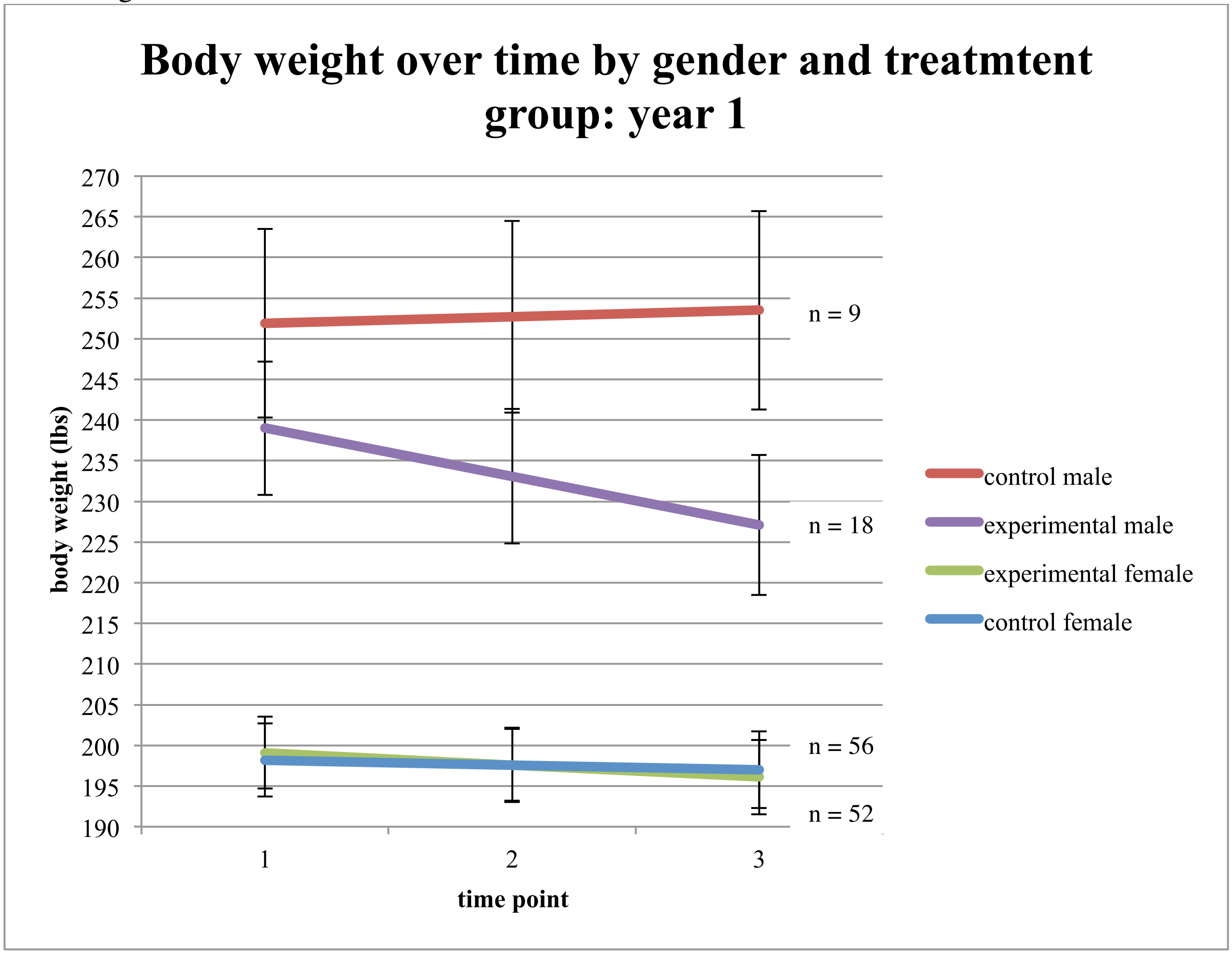
To investigate this further, the table below compares groups. Because these are t-tests they are not controlling for any covariates as the bar charts do.

Table 2.2 Comparing treatment group and gender using t-tests

Group	t-test difference between control and experimental group weight change over year 1 p-value (2-tailed)		
Males	0.013		
Females	0.328		
		t-test difference between change in weight over yr1 and zero (mean ± SD)	p-value (2 tailed; vs 0)
Male control (n = 9)		1.6 ± 8.0	0.561
Female control (n = 56)		-1.4 ± 10.1	0.292
Male experimental (n = 18)		-12.0 ± 14.1	0.002
Female experimental (n = 52)		-3.5 ± 11.9	0.038

All bar charts presented are based on Analysis of Variance. The following line graph is based on the mixed model's estimation of means for each gender at each time point.

Figure 2.11



Body weight (lbs) over the first year of the study by treatment group and gender using a mixed model for parameter estimates at each time point. There are 6 months between time points. Error bars are +/- 1 standard error.

At first glance, it may seem disconcerting that the weight values at time point 1 appear to be different for males in the control and experimental group. To test the statistical significance of this difference, an independent samples t-test was used and the average weight for males in the control group and males in the experimental group was not statistically different (p = 0.314; 2-tailed test).

The males in the control groups' average weight at time point 1, 2, and 3 were as follows: 251.9 ± 11.6 pounds, 252.7 ± 11.8 pounds, and 253.5 ± 12.2 pounds. The males in the experimental groups' average weight at time point 1, 2, and 3 were as follows: 239.0 ± 8.2 pounds, 233.1 ± 8.3 pounds, 227.1 ± 8.6 pounds. For females in the experimental group: 199.1 ± 4.4 pounds, 197.6 ± 4.4 pounds, 196.1 ± 4.6 pounds. And, for females in the control group: 198.2 ±4.5 pounds, 197.6 ± 4.6 pounds, and 197.0 ± 4.7 pounds. The change in weight over the first year differs by treatment group and gender. There appears to be much less of a difference in the effect of treatment group in women as compared to men. The three-way interaction between treatment group, time, and gender is significant ($p = 0.02$).

Over the first year of the study, the only group that behaved counter to expectations was the control female group. They lost weight; however, this loss was not significantly different from zero similar to the results of control groups from other studies (Waters, George, Chey, & Bauman, 2012). The intervention very slightly and non-significantly exacerbated this loss in intervention females. For males, the contrast is more clear – males in the control group gained weight over the first year while males in the experimental group lost weight.

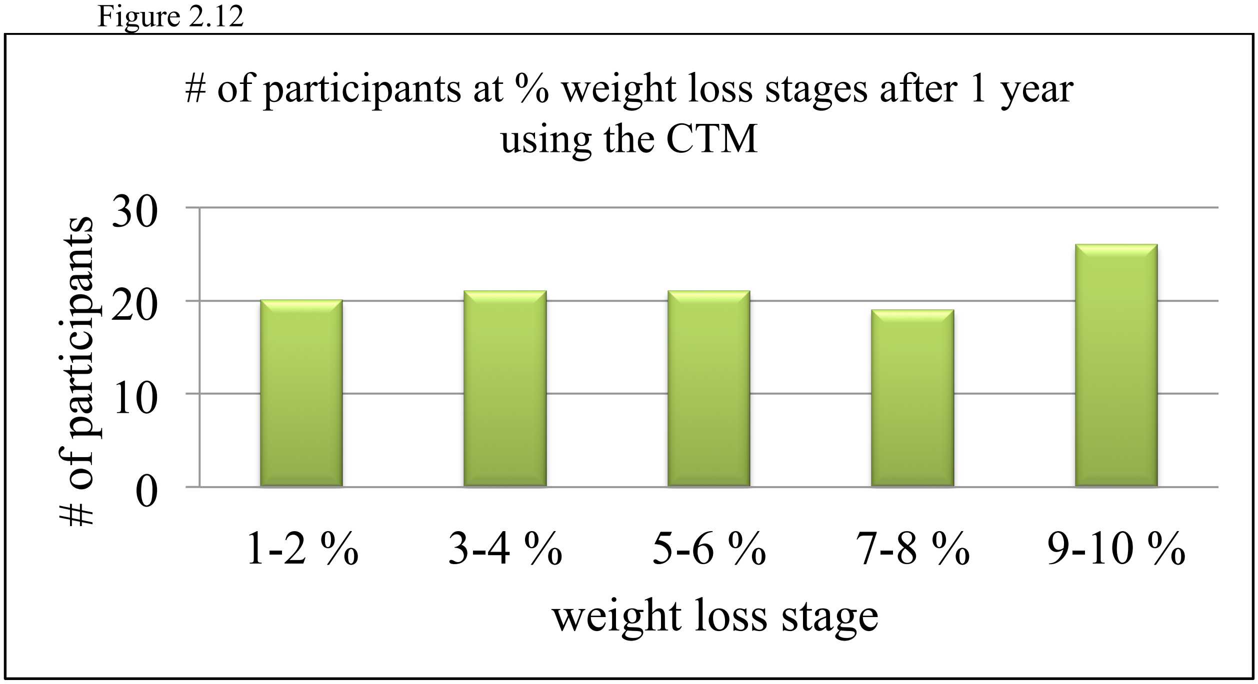
Year 2 results

In year 2, participants in the control group were provided with the same type of scale and access to the online website that participants in the experimental group received in year 1. Their weight loss over the year 2 (time point 5 minus time point 3) was on average -4.2 pounds ± 12.5 ($n = 57$). This loss was significantly different from zero ($p = 0.013$, 2-tailed test). This loss was not significantly different from the average loss of the experimental group in year 1 (-5.7 pounds ± 12.9; n = 70) (p-value for difference = 0.524; 2-tailed).

In year 2, participants who continued in the experimental group from year 1 were ideally to have achieved their 10% weight loss over the first year and the goal for the second year is maintenance. The average weight change was 0.121 pounds ± 10.6, a value not significantly different from zero (p = 0.929) indicating that they successfully maintained their weight loss over the one year period.

Combining the experimental and delayed treatment control group's first year using the CTM intervention, this bar chart shows the number of participants reaching each stage of % body weight lost over the first year:

Figure 2.12

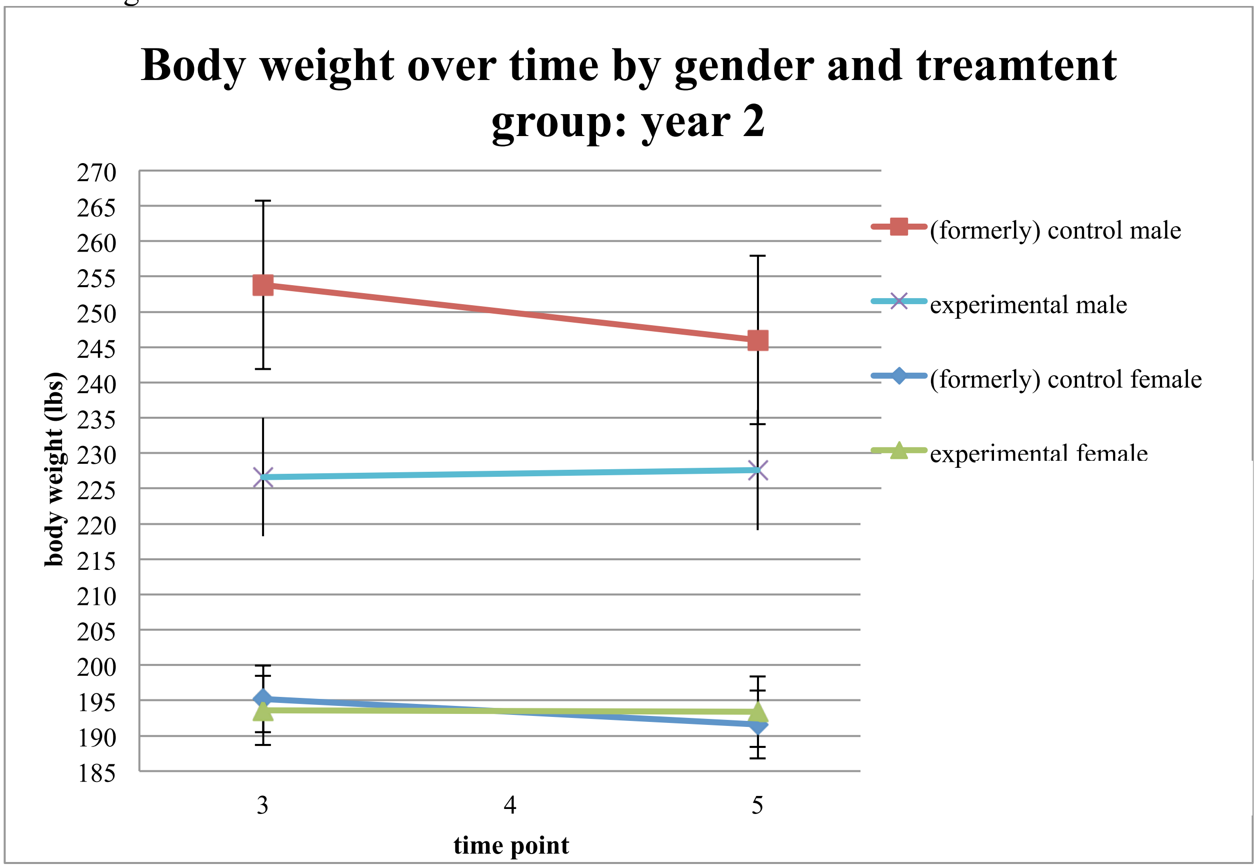


Number of participants reaching weight loss stage of X% of their body weight after 1 year using the CTM.

Finally, the comparisons described above about year 2 were using t-tests and did not take gender into account. The following graph visually displays each group's change in weight over time using estimated marginal means from a random intercept model estimating the line between time point 3 and time point 5. A random intercept random slope model could not be run for the data in the second year because there are only 2 data points. Because a random intercept random slope model was used to estimate a line for time points 1, 2, and 3, and a random intercept only model was used to estimate a line for time points 3 and 5, each estimate is slightly different for time point 3 (For groups control female, control male, experimental female, and experimental male the estimates are as follows for the random slope random intercept model: 197 lbs ± 4.7, 253.3 lbs ± 12.2, 196.1 lbs ± 4.6, and 227.1 lbs ± 8.6, respectively. For the random intercept only model: 195.2 ±4.7, 253.7 ± 11.9, 193.6 ± 4.9, 226.6 ± 8.4). The decision was made to use the estimation from the random slope random intercept model whenever possible (e.g. at time point 3 when including all 4 data points) because this model explained a greater amount of the variability in the response than the random intercept only model.

The following line graph displays linear trajectories for each group using the random intercept model over the second year of the study (in this case, time point 3 was estimated from the random intercept only model because only the second year is being visualized).

Figure 2.13



Body weight (lbs) over the second year of the study by treatment group and gender using a mixed model for parameter estimates at each time point. There are 6 months between time points. Error bars are +/- 1 standard error. In the second year of the study, experimental participants were instructed to maintain lost weight while controls were given access to the CTM for this year.

In the second year, the experimental males maintained the lost weight, whereas the control males (given the intervention) lost weight, but to a lesser degree than the experimental males did in the first year. The amount of weight lost for the control males in year 2 was not significantly different than the experimental males in year 1 ($p = 0.42$). The experimental females continued to lose weight but at a slower rate in the second year, whereas the female controls weight loss accelerated when given access to the intervention

Discussion

The major finding of this study is that the use of frequent weighing and the presentation of individualized visual feedback of weight, alone, without a prescribed diet or exercise plan was effective in producing a slow but sustainable weight loss in obese and overweight males but not females. This same method was also used to examine whether the treatment was effective in helping adults to maintain the weight they lost. Frequent self-weighing and visual feedback produced a change in weight not significantly different from zero in the year following treatment, indicating weight maintenance.

Comparison with published studies using similar interventions

The amount of weight lost during the first year of intervention treatments was relatively small: 5.7 ± 12.9 pounds (2.6 ± 5.9 kgs) for the first group (experimental) and 4.2 ± 12.5 pounds (1.9 ± 5.7 kgs) for the second group (controls). In terms of percent body weight lost, the experimental participants lost an average of 2.7± 5.9 percent of their body weight over the first year, while participants in the control group lost an average of 0.5 ± 4.8 percent of their body weight over the first year. In the second year, the experimental group lost an average of 0.0± 5.1 percent of their starting weight and the control group (treated in the second year) lost an average of 1.9 ± 5.4 percent of their starting weight. Over the full two years of the study, the experimental group lost an average of 3.1 ± 7.2 percent of their baseline weight while the control group when placed on the experimental treatment lost an average of 2.6 ± 6.2 percent of their baseline weight.

Studies using comparable designs and samples report much greater losses. According to a meta-analysis of weight-loss maintenance, after 1 year participants maintained 67% of their weight loss (Anderson, Konz, Frederich, & Wood, 2001). For example, Steinberg and colleagues found an average of 6.13 kg loss (13.5 pounds) over 6 months (Steinberg et al., 2013). This would mean that participants in Steinberg et al.'s trial would sustain about 9 lbs of loss after one year, still far surpassing the losses found in this study. At 2 years, Anderson and colleagues' estimate drops to 44% (Anderson et al., 2001), which would translate to a 6 pound sustained loss for Steinberg's participants. In the present study only the experimental group was followed for 2 years with treatment and the loss at 2 years on average was 6.5 ± 15.3 pounds. In the control group, which only received one year of treatment, the mean loss at 2 years was 5.5 ± 13.7 pounds. These estimates are very close to the projected weight loss maintenance in studies of shorter duration and more intense treatment.

Tsai & Wadden performed a review of commercially available weight loss diets in the United States (Tsai & Wadden, 2005). The section most comparable to this study would be 'Internet-Based Commercial Weight Loss Programs'. Tsai & Wadden found that participants using eDiets.com lost 1.1% of their weight at the end of one year. This was considerably less than those given a weight loss manual (lost 4% of their weight). The authors note that these percentages lost are likely best case scenario as there were more than a dozen in-person weigh-in visits over the year in addition to 5 short psychological consultations.

A randomized controlled trial of the commercially available program, Weight Watchers, may also be of use for comparison due to the participant characteristics and sample comparison (Heshka et al., 2003). The sample had an average BMI of 33.7 kg/m^2 and was 85% female, so in these respects it was similar to the sample used in this study (average BMI of 33.5 and approximately 75% female). In addition, the comparison group to the Weight Watchers group was a self-help group. Participants in this group received a 20 minute meeting with a dietitian at baseline and had materials available. Using the intent-to-treat analysis results, after 12 months the Weight Watchers group lost 4.3± 0.4 kgs and the self-help group lost 1.3 ± 0.4 kgs. After 24 months, the weight watchers group lost 2.9 ± 0.5 kgs and the self-help group lost an average of 0.2 ± 0.4 kgs (Heshka et al., 2003). In terms of body weight percentage lost, participants using Weight Watchers lost an average of 5.3% of their body weight after 6 months; this was the maximum average percent of body weight loss reached (Tsai & Wadden, 2005). This percentage decreased to 3.2% at 24 months. The self-help group lost an average of 1.5% at 6 months; this decreased to 0% change at 24 months (Tsai & Wadden, 2005). Interestingly, our experimental group, which used a self-directed weight loss intervention, had results closer to the weight watchers group at two years than the self-help group. When considering the resources put into weight watchers and the expense, the CTM is a much simpler and cost-effective way for people to lose weight. That being said, it is possible that for some individuals, the social support available in a group program may be a factor in their success.

In these studies used for comparison, initial weight loss is greater but weight regain ensues. One idea may be to aim for the largest weight loss possible, assuming a certain percentage regain, and strive for the net weight loss that is the greatest. The CTM approach avoids this and encourages slow and steady maintained loss. There is reason to believe that this may be healthier as literature has shown that weight fluctuations are adversely associated with long-term health (Lissner et al., 1991).

Though the amount of weight loss produced by the CTM was small, this has to be put into perspective with the intensity of the program. This is a low-cost and low-intensity intervention that can be disseminated easily through the internet. This type of program would be feasible for healthcare practitioners to carry out with a moderate number of patients, allowing them to allocate their time to those that require more support. From the patient's perspective, this would enable one to manage one's own weight while knowing that the process is being overseen. Most importantly, the weight that was lost was kept off during the second year of the study.

Rate of weight loss

A major part of the conceptual development of the CTM was a focus on slow weight loss. It is currently believed that a faster rate of weight loss initially predicts better long term outcomes than losing weight more slowly (Astrup & Rossner, 2000; Elfhag & Rossner, 2005; Rissanen, Lean, Rossner, Segal, & Sjostrom, 2003). Despite the intuitive appeal that losing weight more rapidly at the beginning of a weight loss procedure would reinforce those behaviors that contribute to the weight loss better than a slow weight loss. A careful review of the literature, however, suggests that the evidence supporting this idea is not as strong as currently believed.

The major studies used to add support to the idea that more rapid initial weight loss is more beneficial to sustained weight loss are correlational (e.g.Rissanen et al., 2003), not experimental. If one finds individuals who lose weight more rapidly are able to sustain that weight better than those who lose weight more slowly does not necessarily mean that it was the more rapid weight loss that caused the better weight loss retention. Rather, it is equally as likely that initial weight loss may be a proxy for the motivation is lose weight. .

One of the few experimental studies is cited in Astrup & Rossner's (2000) review was by Toubro and Astrup (1997). The authors state:

> "Toubro & Astrup randomized 43 obese adults to 8 weeks of a Very Low Energy Diet (VLED)(2MJday-1) to produce more rapid weight loss or 17 weeks of conventional diet (5MJday-1) to produce slower weight loss, and the difference in duration was targeted in order to reach a similar weight loss (10). After the weight loss phase, all patients were enrolled in a 1 year weight maintenance programme with a follow-up 2 years after the weight loss. The weight loss achieved by the 8 and 17 weeks treatment programmes were similar (13.6 kg vs. 13.6 kg), while the rate of weight loss in the low energy group was twice that in the conventional group (1.6kg week-1 vs. 0.8 kg week-1). After adjusting for possible confounders Toubro & Astrup found that the weight loss maintained in the low energy group was greater by 2.4 kg after 1 year and 3.0 kg after 2 years, although none of these differences reached statistical significance (10). At least this study does not support that a rapid weight loss rate influences long-term outcome adversely."

However, the original study was not intended to manipulate rate of weight loss. Instead, it compared three equicaloric diets of three different nutrient compositions: ad lib, low fat, and a high carbohydrate diet. After initial weight loss participants were randomized to a weight maintenance intervention – either ad lib (low fat high CHO) or fixed energy intake (Toubro & Astrup, 1997). After the weight maintenance year, the ad lib group had gained 0.3 kgs and the fixed energy intake group had gained 4.1 kgs. In Table 2 the weight regained at follow up (one year after the weight maintenance phase ended), participants in the ad lib group regained 5.4 kgs (out of 13.5 kgs lost) and participants in the fixed energy intake group regained 11.3 kgs (out of 13.8 kgs lost). All of these results are based on the randomization of participants to the *weight maintenance diet.* Results tracking back to whether participants initially lost weight at the faster or slower rate are not discussed. Rate of weight loss group is not mentioned until the discussion, where the authors say *"We found that the rate of initial weight loss had no effect on subsequent weight maintenance, which suggests that different procedures to induce weight loss may be equally suitable providing they are followed by an effective, long term dietary programme of weight maintenance. However, with a less intensive weight maintenance programme than the one in this study, we would anticipate the long term outcome after an initial weight loss to be unsatisfactory"* (Toubro & Astrup, 1997, Discussion section, para. 2)

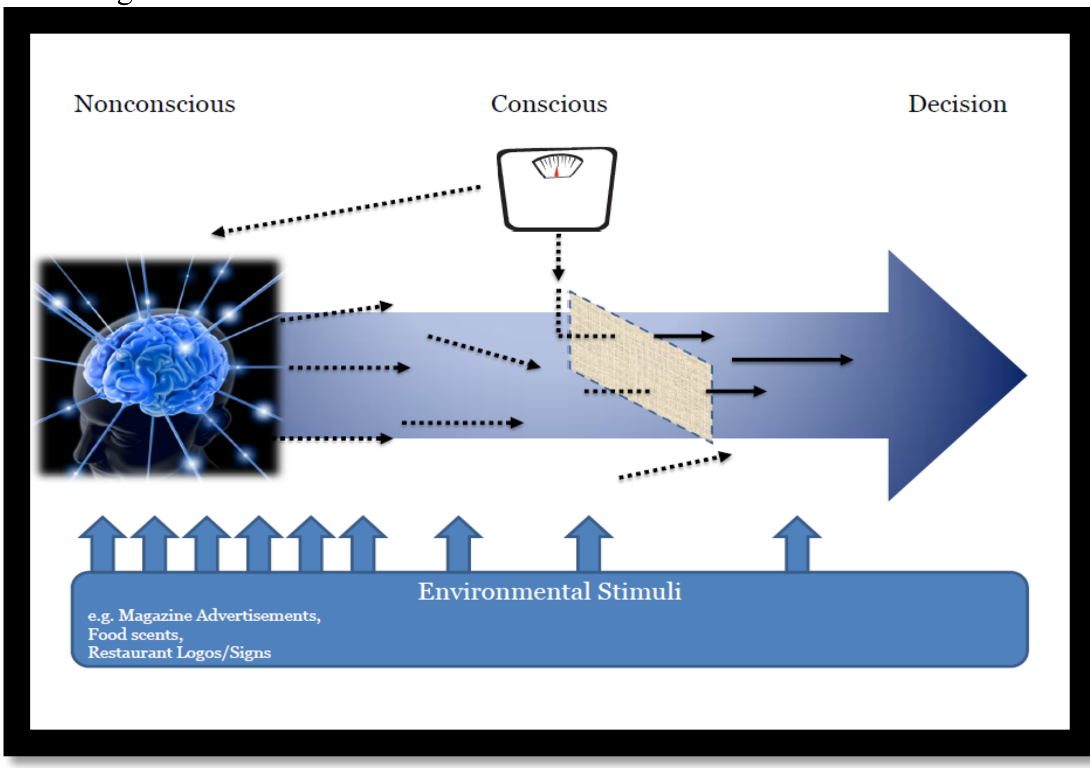
Using principal components analysis, researchers publishing results of the Look AHEAD trial found that slower and steadier weight loss was associated with better maintenance 4 years after starting the study (Neiberg et al., 2012). However, both slow and steady weight loss and initial quick weight loss were predictors of long term success.

The most recent discussion of rate of loss as a predictor of success at weight concluded that the idea initial rate losing weight is superior to losing weight more slowly to sustain the weight loss is nothing other than a myth (Casazza et al., 2013) and this is justified using two of the references described previously (Astrup & Rossner, 2000; Nackers, Ross, & Perri, 2010).

Why did the CTM work better for males than females?

The primary post hoc finding of this study was that the CTM worked for males but not females. There are a several reasons why men might respond more favorably to the CTM than women. In discussing these possibilities, it is helpful to think contextually about how the CTM might produce a weight loss. Consider the broad view that the United States population has experienced a steady increase in body weight for several decades and this increase has paralleled a rise in the number of food and beverage varieties available (United States Department of Agriculture (USDA) Economic Research Service, 2013). Being continuously presented with stimuli that physiologically and psychologically encourage consumption may be one factor contributing to this increasing body weight trend. Providing individuals with a tool to monitor their weight could produce a shift in control from the environment to the individual by demonstrating that personal decisions and actions have consequences over time. Then, the following conceptual framework can serve to describe the process of how the CTM might facilitate weight loss and is explained in the next paragraph:

Figure 2.14



Conceptual diagram proposing potential mechanism of the CTM

Elements of the environment stimulate individuals both on conscious and nonconscious levels. This has been exemplified in the literature on priming (Van den Bussche, Van den Noortgate, & Reynvoet, 2009). For example, Harris, Bargh, and Brownell experimentally demonstrated that food commercials can influence the amount children consume while watching television (Harris, Bargh et al. 2009). The commercials act nonconsciously to increase the availability of associations and memories of foods related to those visually displayed. These commercials may bring food to attention when without the commercial attention may have been focused upon something that does not trigger eating behaviors. Likewise, the diagram suggests that stimuli such as magazine advertisements, food scents, and restaurant signs can act at the level of the nonconscious as well as the conscious. This notion has been supported by research in social psychology both concretely (Vartanian, Herman et al. 2008) and more abstractly (Ferguson and Zayas 2009). The diagram proposes that nonconscious level stimuli may also affect the thoughts that are brought to conscious attention.

This conceptual framework helps to provide background as to why men might respond better to the CTM than women. Sociologist and Social Science Theoretician Jeffery Sobal suggests that women are, from a young age, bombarded with stimuli to counter the environmental ‘eat’ stimuli – such as dieting ads, dieting books, their weight, so this is very much already a part of their conscious and nonconscious (Sobal, personal communications, 2011-2012). To support this view, studies have found that a greater proportion of women reported dieting than men (e.g. Jeffery, Adlis, & Forster, 1991). These ideas of weight and weight loss are interwoven into many existing cognitive schemas. The addition of having women weigh themselves daily may not be markedly different from what is already on their mind and fits with many mental pathways. So, the increase in conscious and nonconscious attention on weight and dieting is minimal, and so is their response. However, culturally men are less likely to have dieting and weight control at the forefront of their mind. Behaviorally directing men’s attention to their weight by showing them weights on a daily basis and providing evidence of a graph of their weight showing that if they do ‘experiments’ with eating and or exercise, there is an effect on their weight, may be more meaningful and surprising as it is not something interwoven into their ways of thinking.

Another possibility is related to how men and women think and relate to the world differently. The CTM was developed to proceed in a very logical, rational, and objective way. It does not create a socially supportive environment for weight loss and relies on the individual to take care of themselves and learn what works for them. It is possible that a greater proportion of males' thinking patterns and way of viewing the world is amenable to the graphical, 'trial and error' approach of the CTM; whereas a larger proportion of women operate with greater emotional and perceived senses than a logical reasoning and objective numerical approach. This is not to say that there are not women that do well with a more logical approach and men that do well with emotionally based weight loss; this is merely a suggestion that it is possible that there are a greater proportion of men that relate to this approach as compared to women.

Limitations and contributions

This study has a number of limitations. First, the participants consisted of a self-selected sample of individuals that were interested in losing weight. Additionally, these individuals were members of a campus wellness organization that is optional for employees, meaning that these people may have had a heightened concern about their health. The sample was not racially and ethnically diverse and so generalizations about how the CTM may influence weight in diverse populations cannot be made from this study. Similarly, conclusions about different age ranges or stages in life (e.g. premenopausal vs. postmenopausal) cannot be made as this was not a focus of the study. Since persons with diabetes mellitus, pregnant or planning to become pregnant, or reporting a history of or current eating disorder were not included in the sample, inferences cannot be made about these populations either. The most concerning limitation is that we are unable to separate the degree to which the CTM was the factor causing the weight change versus the fact that participants were cognizant of the study team's oversight. If participants did not enter a minimum of 3 weights per week, they were sent an email reminding them that they had not entered a sufficient number of weights for that week. We tried to keep investigator involvement and participants' desire to please the investigator at a minimum; no rewards were provided or congratulatory remarks were sent as a rule when stage changes were made. Despite these efforts, for many participants, knowing that someone was watching them may have played a part in their weight loss over the course of the study. Future studies that can more effectively disentangle the degree to which knowing they are being watched contributes to weight loss would be useful. On the other hand, if the purpose of this type of work is to allow for greater dissemination of weight loss techniques to the public, it is reasonable that healthcare practitioners would monitor their patients; in this sense the element of someone overseeing their progress would remain.

It may also be concerning that the treated controls in year two lost less weight then the experimental participants in year one, even though these values were not significantly different from one another. There are several reasons why this might have happened. First, the controls had to wait a full year before finding out what the intervention was. This time could have built anticipation, only to leave the participants feeling disappointed with the simplicity of the intervention. All participants were told at the initial sessions of the objective of the study (slow and sustainable weight loss, no large weight changes) and this deterred some (thus, controls finding out partway through the study that the objective of the intervention was to lose less weight than they desired is not a very likely scenario as they would have withdrawn). It was also indicated that the intervention was a simple behavioral change and did not require any dieting pills or specific diet or exercise plans. When the experimental participants were given their intervention materials, this immediately followed a large group session (or small group recording) where the research supported weight loss strategies were presented in person (or played back) by David Levitsky. Control group participants were given intervention materials when they attended their 12 month (time point 3) weigh in, so the CTM was explained to them briefly in conversation and they were directed to the audio-recorded explanation of the CTM along with the same handout the experimental group was given. It may have been less motivating to hear the ideas behind the CTM through audio recording, or participants may not have watched the recording. This could have affected committment to the program and subsequently affected the weight loss outcome. Finally, control participants were recruited into a weight loss study, so they may have been interested in losing weight and had plans to do so regardless of treatment group.

Despite these limitations, this study makes a meaningful contribution to the existing work on weight control. This is the only study we are aware of that focuses its intervention uniquely on self-weighing (and individualized feedback) without also confounding the comparison with weight loss education lessons as comparable studies tend to use more of a comprehensive approach(Steinberg et al., 2013). Since the control group and experimental group received identical information about weight loss strategies at the initial session (with the exception of the description of the CTM) this factor can be ruled out as having contributed to the weight effects.

Conclusion

In a society that has seen body weights increasing for several decades (athough some subpopulations have leveled off), techniques to reduce weight, even minimally, and sustain this reduction are important. The CTM represents a time and cost effective technique that can be mass disseminated through the internet. Public health strategies such as this one that allow for individuals to understand how the environment is affecting their weight and focus on weight change over time instead of an absolute number or rage can provide a sense of control for people living in a society with a constantly changing food environment.

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APPENDIX 2.1: Information for participants

Caloric Titration Method – Information for Participants

As a participant in this study, you will be testing the effectiveness of an internet-based program called the Caloric Titration Method (CTM). The CTM requires you to weigh yourself every day. The optimal time to do this is the first thing in the morning without clothes. However, you can weight yourself at any time and even fully clothed – what's important is *consistency – weighing yourself at the same time under similar conditions (e.g. similar clothing) every day.* Some people find that placing their scale in an area that makes weighing a convenient part of their daily routine (e.g. placing the scale under your desk in your office) helps to make daily weighing a habit. After weighing yourself using this scale, please enter your weight into the CTM website (url given below), which will show you a visual display of your weight over time. In addition, you will be asked to complete short questionnaires about how well you are doing with the program along with the 47-question survey you fill out every 6 months.

Using the CTM website: The web address to access the CTM program is: http://weightloss.human.cornell.edu/

After entering the website, you'll need to register by entering information which enables the program to maintain your records and allow us to contact you if we think there is a problem. After inputting the information, the program will ask if you want to use the program to lose or maintain your weight.

For the first seven days, you log into the website and enter your weight. The program will calculate your "true" body weight from these seven data points (taking into account the natural fluctuations in body weight that occur day to day) and generate a line that is one percent lower than this body weight. Your task is to make small changes in your daily eating behavior or energy expenditure to slowly reduce your weight to that line. Professor Levistky presented research-supported ways of doing this in the initial information session, which can be sent to you to watch again. We want you to *discover changes that work for you*. After you maintain this weight (one percent below your starting weight) for one week, the dotted line will drop another one percent. You cannot continue to the next stage of weight loss until the program has determined that your weight loss is not different from the current weight level (that the loss has been steadily maintained). So you can't lose weight more rapidly than *one percent at a time*. This will continue until you have lost a maximum of ten percent of your original weight. We then want you to maintain this ten percent weight loss.

We ask that you lose weight slowly and that you enter your weight *at least* 3 times each week. It is important to lose weight slowly and adjust to the changes you make in either your energy intake or expenditure. A healthy weight loss is less than 5 lbs per week. We will be observing your weight graphs on a regular basis and if we see that you are losing or gaining weight too rapidly (more than 5 lbs per week is considered 'too rapidly'), we will contact you to see if there is any problem that requires assistance. If you lose or gain more than 5 lbs per week on two occasions, you will be disqualified from the study it will be suggested that you seek medical attention. We also ask that you use the program consistently, entering your weights at least 3 times each week. If you enter your weight less than 3 times a week without providing the researchers with an explanation, you will be contacted. If this happens on two occasions without explanation, we will ask you to return the scale, fill out questionnaires one more time and withdrawal from the study.

Philosophy behind the CTM: Four of the major concepts behind this procedure are as follows:

1. ***Slow Weight Loss.*** Lose weight slowly in one percent decrements. This gives you time to see if you can sustain these changes and make them part of your lifestyle.

2. ***Visual Feedback.*** Visual feedback of your efforts to control your intake is necessary to change your weight. Daily errors in intake or expenditure that change our weight are too small to detect. Long term recognition of trends in daily weight is necessary to produce sustained changes.

3. ***Changes You Can Live With.*** In order to produce a sustained reduction in weight, you must make changes in your intake or expenditure that work for you. This may mean experimenting with different kinds of changes.

4. ***Sense of Control.*** The CTM should give you a sense that you are in control of your weight – that the actions and behaviors you engage in have consequences. By seeing the daily consequence of your actions (energy intake and expenditure) you will learn that you can control your weight even in an environment that seduces us to overeat. The method is called Caloric Titration because what we have to learn to do is to titrate the amount of calories we need each day in order to produce the weight we desire.

You are welcome contact the research team at any time with questions or concerns:

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Wishing you success!

APPENDIX 2.2: Baseline characteristics by treatment group

Baseline Characteristics				
	Total	Control	Experimental	p-value diff[a]
Age (years)	46.6 ±9.6[b] (n = 144)[c]	48.2 ±9.9 (n = 66)	45.3 ±9.6 (n = 77)	0.071
BMI (kg/m^2)	33.5 ± 5.0 (n = 148)	33.7 ± 5.1 (n = 68)	33.4 ± 5.1 (n = 81)	0.898
Body Weight (kgs)	93.8 ±17.4 (n = 148)	93.1 ±17.9 (n = 68)	94.3± 17.0 (n = 81)	0.690
Body Weight (lbs)	206.7 ± 38.3 (n = 149)	205.3 ± 39.5 (n = 68)	207.8 ± 37.4 (n = 81)	0.690
Height (in)	65.7 ± 3.7 (n = 142)	65.3 ± 3.7 (n = 65)	66.1 ± 3.7 (n = 77)	0.199
Education (years) *Highest level of education completed (select one): 1st grade (1), 2nd grade (2), 3rd grade (3), 4th grade (4), 5th grade (5), 6th grade (6), 7th grade (7), 8th grade (8), 9th grade (9), 10th grade (10), 11th grade (11), 12th grade/finished high school (12), one yr of college (13), two yrs of college (14), three yrs of college (15), four yrs of college (no degree) (16), college degree (17), masters degree (18), doctorate degree (19)*	15.9 ± 2.2 (n = 146)	16.0 ± 2.2 (n = 67)	15.8 ± 2.2 (n = 79)	0.454
Ethnicity (number of participants)				
American Indian	3	2	1	.[e]
Asian	2	2	0	.
African American	6	3	3	.
Hispanic	1	1	0	.
White	144	65	79	0.696
Other (text)	2	0	2	.
In the past year, how many times have you tried to lose	1.6 ± 1.4 (n = 147)	1.7 ± 1.4 (n = 67)	1.6 ± 1.4 (n = 80)	0.088

weight? (choose one) *(0 (0); 1-2 (1); 3-4 (2); 5-6 (3); 7-8 (4); 9-10 (5); >10 (6))*				
In your lifetime, how many times have you tried to lose weight? (choose one) *(0 (1);1-5 (2); 5-10 (3); 10-20 (4); 20-50 (5); 50-100 (6); > 100 (7))*	3.6 ± 1.4	3.7 ± 1.2 (n = 67)	3.5 ± 1.5 (n = 78)	0.400
How important is it for you to lose weight? *(Not at All Important (1) Not Very Important (2) Somewhat Important (3) Very Important (4) Extremely Important (5))*	4.0 ± 0.714	4.0 ± 0.7 (n = 67)	4.0 ± 0.7 (n = 79)	0.644
Are you currently on a diet? *(Yes/No)*[d]	18.5% (n = 146)	19.7 % (n = 66)	17.5% (n = 80)	0.734
Have you attempted to diet in the past? *(Yes/No)*[d]	91.7% (n = 144)	95.5% (n = 66)	88.5% (n = 78)	0.130
On a scale of 1 to 10, how much do you feel in control of your weight (1 being not in control at all, 10 being in full control)?"	4.3 ± 2.0 (n = 144)	4.2 ± 1.9 (n = 68)	4.3 ± 2.1 (n = 76)	0.987
Restraint (TFEQ)	9.8 ± 3.7 (n = 146)	9.9 ± 3.7 (n = 66)	9.7 ± 3.7 (n = 80)	0.663
flexible control (restraint)	2.9 ± 1.5 (n = 146)	2.9 ± 1.6 (n = 66)	2.9 ± 1.4 (n = 80)	0.980
rigid control (restraint)	3.1 ± 1.7 (n = 146)	3.2 ± 1.7 (n = 66)	3.1 ± 1.7 (n = 80)	0.594
Disinhibition (TFEQ)	10.1 ± 3.2 (n = 146)	9.8 ± 3.1 (n = 66)	10.3 ± 3.3 (n = 80)	0.353
Hunger (TFEQ)	6.6 ± 3.0 (n = 145)	6.5 ±2.9 (n = 65)	6.6 ± 3.0 (n = 145)	0.850
Weight Locus of Control (WLOC)	8.8 ± 2.9 (n = 143)	8.9 ± 2.9 (n = 66)	8.8 ± 2.8 (n = 77)	0.812
Self Mastery	19.1 ± 2.9 (n = 143)	18.9 ± 3.2 (n = 64)	19.1 ± 2.8 (n = 79)	0.629
Quality of life – Physical Functioning (PF)	82.8 ± 18.7 (n = 147)	83.9 ± 17.3 (n = 67)	81.9 ± 19.7 (n = 80)	0.534
Quality of life – Role Physical (RP)	83.3 ± 18.7 (n = 147)	84.7 ± 18.7 (n = 67)	83.3 ± 18.7 (n = 80)	0.400
Quality of life – Bodily	69.8 ± 20.2	71.1 ± 18.3	68.8 ± 21.7	0.482

Pain (BP)	(n = 147)	(n = 67)	(n = 80)	
Quality of life – General Health (GH)	63.6 ± 19.3 (n = 147)	65.9 ± 17.7 (n = 67)	61.6 ± 20.6 (n = 80)	0.179
Quality of life – Vitality (VT)	50.3 ± 16.6 (n = 147)	53.5 ± 16.5 (n = 67)	47.6 ± 16.3 (n = 80)	0.030
Quality of life – Social Functioning (SF)	79.3 ± 24.2 (n = 147)	82.8 ± 21.9 (n = 67)	76.3 ± 25.7 (n = 80)	0.100
Quality of life – Role Emotional (RE)	79.7 ± 23.7 (n = 147)	83.1 ± 21.8 (n = 67)	76.8 ± 25.0 (n = 80)	0.105
Quality of life – Mental Health (MH)	69.5 ± 17.6 (n = 147)	71.3 ± 17.5 (n = 67)	68.0 ± 17.6 (n = 80)	0.257
Quality of life – Physical Component Summary (PCS)	50.2 ± 8.0 (n = 147)	50.6 ± 6.2 (n = 67)	49.9 ± 9.3 (n = 80)	0.635
Quality of life – Mental Component Summary (MCS)	45.5 ± 11.6 (n = 147)	47.3 ± 11.2 (n = 67)	44.1 ± 11.8 (n = 80)	0.894

[a] p-value for the difference between control and experimental group means (independent samples, 2-tailed test)
[b] mean ± standard deviation
[c] n may vary because of different data collection mechanisms (body weight taken in person, age reported via online survey)
[d] For questions with yes/no answers, the percentage that reported 'yes' is shown; the p-value column displays the p-value of the chi-square statistic for a two tailed-test
[e] when the expected cell count is less than 5, the chi-squared statistic cannot be calculated

APPENDIX 2.3: Mixed model syntax and parameter estimates

```
MIXED weight BY ID randcode WITH timept
  /CRITERIA=CIN(95) MXITER(10) MXSTEP(1) SCORING(1)
SINGULAR(0.000000000001) HCONVERGE(0, ABSOLUTE)
    LCONVERGE(0, ABSOLUTE) PCONVERGE(0.000001, ABSOLUTE)
  /FIXED=randcode timept randcode*timept | SSTYPE(3)
  /METHOD=REML
  /RANDOM INTERCEPT timept|subject(ID) COVTYPE(UN)
/PRINT solution
 /SAVE=RESID PRED.
```

Type III Tests of Fixed Effects[a]

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	147.112	4091.422	.000
randcode	1	147.112	.550	.459
Timept	1	140.233	9.620	.002
randcode * timept	1	140.233	5.056	.026

a. Dependent Variable: obj Weight (lbs) .

Estimates of Fixed Effects[a]

Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Intercept	210.573466	4.399127	147.400	47.867	.000	201.879961	219.266971
[randcode=1]	-4.828536	6.508613	147.112	-.742	.459	-17.690993	8.033921
[randcode=2]	0[b]	0	.	.	.	.	.
timept	-2.595492	.666447	142.159	-3.895	.000	-3.912918	-1.278066
[randcode=1] * timept	2.181587	.970244	140.233	2.248	.026	.263390	4.099783
[randcode=2] * timept	0[b]	0	.	.	.	.	.

a. Dependent Variable: obj Weight (lbs) .
b. This parameter is set to zero because it is redundant.

APPENDIX 2.4: Baseline characteristics by gender

Baseline Characteristics by Gender				
	Total	Males	Females	p-value diff[a]
Age (years)	46.6 ±9.6[b] (n = 144)[c]	45.4 ± 8.4 (n = 27)	46.9 ± 10.1 (n = 116)	0.488
BMI (kg/m^2)	33.5 ± 5.0 (n = 148)	33.7 ± 3.6 (n = 27)	33.4 ± 5.4 (n = 115)	0.792
Body Weight (kgs)	93.8 ±17.4 (n = 148)	110.3 ±14.7 (n = 27)	90.1 ±15.7 (n = 122)	0.000
Body Weight (lbs)	206.7 ± 38.3 (n = 149)	243.1 ± 32.3 (n = 27)	198.6 ± 34.7 (n = 122)	0.000
Height (in)	65.7 ± 3.7 (n = 142)	71.2 ± 2.7 (n = 27)	64.4 ± 2.5 (n = 115)	0.000
Education (years) *Highest level of education completed (select one): 1st grade (1), 2nd grade (2), 3rd grade (3), 4th grade (4), 5th grade (5), 6th grade (6), 7th grade (7), 8th grade (8), 9th grade (9), 10th grade (10), 11th grade (11), 12th grade/finished high school (12), one yr of college (13), two yrs of college (14), three yrs of college (15), four yrs of college (no degree) (16), college degree (17), masters degree (18), doctorate degree (19)*	15.9 ± 2.2 (n = 146)	16.5 ± 1.9 (n = 26)	15.8 ± 2.2 (n = 120)	0.079
Ethnicity (number of participants)	3	2	1	.[e]
American Indian	2	2	0	.
Asian	6	5	1	.
African American	1	0	0	.
Hispanic	144	117	27 (96.3%)	0.419
White	2	(91.8%)	1	.
Other (text)		1		
In the past year, how many times have you tried to lose weight? (choose one) *(0 (0); 1-2 (1); 3-4 (2); 5-6 (3); 7-8 (4); 9-10 (5); >10*	1.6 ± 1.4 (n = 147)	1.2 ± 1.2 (n = 27)	1.7 ± 1.4 (n = 120)	0.140

(6))				
In your lifetime, how many times have you tried to lose weight? (choose one) *(0 (1);1-5 (2); 5-10 (3); 10-20 (4); 20-50 (5); 50-100 (6); > 100 (7))*	3.6 ± 1.4 (n = 145)	3.0 ± 1.3 (n=27)	3.7 ± 1.4 (n = 118)	0.017
How important is it for you to lose weight? *(Not at All Important (1) Not Very Important (2) Somewhat Important (3) Very Important (4) Extremely Important (5))*	4.0 ± 0.714 (n = 146)	3.7 ± 0.7 (n = 27)	4.1 ± 0.7 (n = 119)	0.007
Are you currently on a diet? *(Yes/No)*[d]	18.5% (n = 146)	22.7% (n = 27)	22.6% (n = 119)	0.997
Have you attempted to diet in the past? *(Yes/No)*[d]	91.7% (n = 144)	76.9% (n = 26)	94.9% (n = 118)	0.003
On a scale of 1 to 10, how much do you feel in control of your weight (1 being not in control at all, 10 being in full control)?"	4.3 ± 2.0 (n = 146)	5.2 ± 2.0 (n = 27)	4.1 ± 1.9 (n = 119)	0.010
Restraint (TFEQ)	9.8 ± 3.7 (n = 146)	8.1 ± 3.3 (n = 27)	10.2 ± 3.7 (n = 119)	0.009
flexible control (restraint)	2.9 ± 1.5 (n = 146)	2.2 ± 1.1 (n = 27)	3.1 ± 1.5 (n = 119)	0.001
rigid control (restraint)	3.1 ± 1.7 (n = 146)	2.5 ± 1.6 (n = 27)	3.3 ± 1.7 (n = 119)	0.042
Disinhibition (TFEQ)	10.1 ± 3.2 (n = 146)	8.7 ± 3.7 (n = 27)	10.4 ± 3.0 (n = 119)	0.013
Hunger (TFEQ)	6.6 ± 3.0 (n = 145)	6.0 ± 3.2 (n = 27)	6.7 ± 2.9 (n = 118)	0.260
Weight Locus of Control (WLOC)	8.8 ± 2.9 (n = 143)	8.0 ± 2.2 (n = 26)	9.0 ± 3.0 (n = 117)	0.101
Self Mastery	19.1 ± 2.9 (n = 143)	18.2 ± 2.5 (n = 27)	19.3 ± 3.1 (n = 116)	0.091
Quality of life – Physical Functioning (PF)	82.8 ± 18.7 (n = 147)	89.1 ± 11.8 (n = 27)	81.4 ± 19.6 (n = 120)	0.010
Quality of life – Role Physical (RP)	83.3 ± 18.7 (n = 147)	89.4 ± 13.7 (n = 27)	81.9 ± 19.5 (n = 120)	0.062
Quality of life – Bodily Pain (BP)	69.8 ± 20.2 (n = 147)	76.6 ± 19.0 (n = 27)	68.3 ± 20.2 (n = 120)	0.052
Quality of life – General Health (GH)	63.6 ± 19.3 (n = 147)	61.5 ± 11.6 (n = 27)	63.6 ± 19.3 (n = 147)	0.396

Quality of life – Vitality (VT)	50.3 ± 16.6 (n = 147)	53.5 ± 13.1 (n = 27)	49.6 ± 17.2 (n = 120)	0.196
Quality of life – Social Functioning (SF)	79.3 ± 24.2 (n = 147)	84.7 ± 18.1 (n = 27)	78.3 ± 25.3 (n = 120)	0.194
Quality of life – Role Emotional (RE)	79.7 ± 23.7 (n = 147)	85.5 ± 20.5 (n = 27)	78.4 ± 24.3 (n = 120)	0.159
Quality of life – Mental Health (MH)	69.5 ± 17.6 (n = 147)	72.4 ± 13.3 (n = 27)	68.9 ± 18.4 (n = 120)	0.351
Quality of life – Physical Component Summary (PCS)	50.2 ± 8.0 (n = 147)	52.0 ± 6.2 (n = 27)	49.8 ± 8.4 (n = 120)	0.206
Quality of life – Mental Component Summary (MCS)	45.5 ± 11.6 (n = 147)	47.4 ± 9.3 (n = 27)	45.1 ± 12.1 (n = 120)	0.370

[a] p-value for the difference between means for males and females means (independent samples, 2-tailed test; or if responses are yes/no, the p-value for the difference using a Pearson Chi-Square test)
[b] mean ± standard deviation
[c] n may vary because of different data collection mechanisms (body weight taken in person, age reported via online survey)
[d] For questions with yes/no answers, the percentage that reported ‘yes’ is shown; the p-value column displays the p-value of the chi-square statistic for a two tailed-test
[e] when the expected cell count is less than 5, the chi-squared statistic cannot be calculated

CHAPTER 3

DAILY WEB-BASED WEIGHT MONITORING

FOR OVERWEIGHT AND OBESE ADULTS:

A LONGITUDINAL ANALYSIS OF PSYCHOLOGICAL FACTORS

Introduction

It is believed that frequent self-weighing may increase body dissatisfaction and negative mood states such as anxiety and depression, and lowers self-esteem through a focus on weight. Some researchers have raised the assertion that frequent self-weighing may adversely affect the individual psychologically (Dionne & Yeudall, 2005; Klos, Esser, & Kessler, 2012; Neumark-Sztainer, Van den Berg, Hannan, & Story, 2006; Ogden & Evans, 1996; V. Quick, Larson, Eisenberg, Hannan, & Neumark-Sztainer, 2012). Others have suggested lack of negative psychological effect (LaRose et al., 2012; Wing et al., 2007), or even psychological improvement occurs with self-weighing (Gokee-Larose, Gorin, & Wing, 2009; Welsh, Sherwood, VanWormer, Hotop, & Jeffery, 2009).

Some research assessing self-weighing and negative psychological consequences focuses on weight control behaviors deemed detrimental, such as fasting (Klos et al., 2012). This research is also done primarily in adolescents (Neumark-Sztainer et al., 2006; Ogden & Evans, 1996; Quick et al., 2012) or young adults (Klos et al., 2012; Quick et al., 2012). However, the non-adult brain may respond differently to data than the adult brain (Casey, Jones, & Hare, 2008). Engaging in a behavior that is potentially harmful for adolescents (e.g. fasting, skipping breakfast) may be benign in full-grown and developed adults that would derive a health benefit from weight loss.

Much of the research suggesting negative effects of weighing is correlational in nature, not using experimental designs. Self-weighing was not evaluated as an intervention, which is justifiable in populations like adolescents or young adults for which there are epidemiological evidence to support the belief that weighing is associated with unhealthful weight control practices(Neumark-Sztainer et al., 2006; Quick et al., 2012; Quick, Loth, Maclehose, Linde, & Neumark-Sztainer, 2013). To assess whether self-weighing causes adverse psychological outcomes, an experimental design would need to be employed where self-weighing is isolated as the intervention. The present study does that. This chapter assesses changes in psychological factors – perceived control over weight, weight locus of control, self mastery, and quality of life – as they occured in a group randomly assigned to self-weigh frequently and receive a visual of their weight history compared to a no-treatment control group.

This chapter addresses specific aim III: “to elucidate the relationship between weight trajectories and perceived sense of control over life events and body weight as well as mental and physical aspects of quality of life in adults.” It was hypothesized that weight loss would be associated with enhanced feelings of perceived personal control over body weight, more internal weight locus of control, and favorable changes in quality of life.

Methods

A web-based survey was administered at baseline, and at months 6, 12, 18, and 24 for a total of 5 data collection time points. Some questions were asked only at baseline, others at baseline and the completion of the study, and others were asked repeatedly, each of the 5 times the survey was administered.

Baseline individual characteristics and dieting history

At baseline, participants were asked for basic social/biological information including their age, height, and weight. In addition, gender was considered a 'social/biological' variable as it was used as a proxy for sex. Though it is theoretically possible for gender to change over the course of the study, there was no reason to believe that this was the case for any participant in this particular sample, so gender was treated as a fixed variable. Other individual characteristics collected at baseline were years of education completed (self-report).

To asses dieting history and importance of losing weight, questions were included about the following: how important the participant felt it was to lose weight, how many times they had lost weight in the past year, how many times they had lost weight in their lifetime, whether they were currently on a diet, if they had dieted in the past, if they had dieted in the past, how many months out of the previous year they had been on a diet, and the success of their past diets.

Other variables were assessed based on attendance of initial sessions and participation in the study. These included whether the initial session was in a large group and presented by Dr. David Levitsky live versus in a smaller group or one on one and an audio recording of the live session was presented, whether participants entered the study in the first wave (starting in September of 2010) or second wave (starting in late October/early November of 2010), and if participants continued participation, formally withdrew from the study, or were lost to follow-up.

Baseline and endpoint (bookend) measures: Three Factor Eating Questionnaire

Stunkard and Messick (1985) developed the Three Factor Eating Questionnaire (TFEQ) to measure three components of eating behavior: 'cognitive restraint of eating', 'disinhibition', and 'hunger'. This tool improved upon previous assessments of dietary restraint by acknowledging that the scores were influenced heavily by change in body weight. The TFEQ assesses intentions of the individual as compared to behavioral caloric restriction and weight change. The TFEQ measures the respondent's perception of their eating behavior. The TFEQ has been used widely in the literature. Lowe and Thomas (Lowe & Thomas, 2009) review its history and applications in different samples.

Due to the pervasive use of the Three Factor Eating Questionnaire in weight control literature (e.g. Butryn, Phelan, Hill, & Wing, 2007; G. D. Foster, Wadden, Kendall, Stunkard, & Vogt, 1996; Savage, Hoffman, & Birch, 2009), this scale was also included at baseline and at the endpoint of the study to assess relationships with the three eating behaviors measured (cognitive restraint, disinhibition, and hunger) and weight change. Generally, cognitive restraint is believed to be protective against weight gain and disinhibition is positively related to weight gain and higher weights (Ohsiek & Williams, 2011). Ohsiek and Williams (2011) review studies assessing dietary restraint and disinhibition and the relationship in preventing weight regain. Due to the times at which the TFEQ was administered for this study (baseline and endpoint) and lack of a midpoint assessment, weight regain could not be assessed in this study and thus is not discussed further.

The TFEQ factors have been correlated with weight and BMI cross sectionally, but have more seldom been used to predict weight change over time. Of note, many studies discuss restraint and changes in weight but use other measurement tools such as the Restraint Scale (Herman & Mack, 1975). Studies that use alternative measures of restraint other than the Three Factor Eating Questionnaire are not discussed here as differences in psychometric properties may be responsible for the differences in findings. Bjorvell, Rossner, & Stunkard (1986) found that cognitive restraint was associated with weight loss over a year, and that this relationship became stronger after 2 years and 2 ½ years (Björvell, Rössner, & Stunkard, 1986). In a prospective longitudinal analysis of women, Savage, Hoffman & Birch (2009) found that baseline disinhibition predicted weight gain over time and increases in restraint over time correlated with decreases in weight (Savage et al., 2009). Bryant, Caudwell, Hopkins, King, & Blundell (2012) examined relationships between baseline scores of the TFEQ and change in weight over 3 months in an exercise intervention for weight loss. Although an inverse relationship was found between baseline disinhibition and weight loss over the course of that study, baseline restraint was not found to have a relationship with weight loss.

In weight loss studies, decreases in disinhibition and hunger and increases in restraint are related to weight loss (Bryant et al., 2012). Bryant and colleagues (2012) found a statistically significant increase in dietary restraint and decreases in disinhibition and hunger were associated with weight loss (Bryant et al., 2012). The authors also analyzed the data according to responders and nonresponders and found that there was no significant difference in the change in disinhibition or hunger but responders increased in restraint (+2.37) which significantly differed from the change in nonresponders (+0.7). This study did not have a control group so interpretations provide weak evidence about causality. In a group of overweight Turkish adults, researchers found a statistically significant relationship between disinhibition and hunger and weight change (Bas & Donmez, 2009). Both of these factors significantly decreased with treatment. No significant relationship was found between restraint score and weight change.

Repeated measurements: perceived control and quality of life

In addition to asking sociodemographic questions and about past dieting history, this survey used three other separate questionnaires: Weight Locus of Control (Saltzer, 1982), Self Mastery (Pearlin, Lieberman, Menaghan, & Mullan, 1981), and the SF-36 (Ware & Sherbourne, 1992). Surveys were administered via an Institutional Review Board-recommended survey vendor, Qualtrics. To increase the chances that participants would complete the survey every six months, the number of items was limited to compromise brevity and comprehensiveness.

Perceived control: control question, weight locus of control, and self mastery

Control Question

The question was asked at each of five time points, very directly assessing perceived control. This question was “Overall, how much do you feel in control of your weight?” with answers ranging from 1 (not in control) to 10 (in full control).

Weight Locus of Control (WLOC)

The Weight Locus of Control (WLOC) scale consists of 4 items with forced-choice response categories (Saltzer, 1982). This scale was designed as an adaptation of Rotter's Internal-External Locus of Control (LOC) Scale (Rotter, 1966), which is predictive of a personality trait that is relatively stable over time. The 10 item original LOC scale does not focus specifically on weight, but on perceptions regarding why events happen. Someone with an internalized locus of control believes that they are the primary determinant of events in their life, while someone with an externalized locus of control believes that forces outside of themselves, like others or chance, determine outcomes in their life. With respect to weight loss this concept has been used to predict success, and usually but not always finding that those with an internalized locus of control are more likely to be able to lose weight as compared with those with externalized locus of control (Adolfsson, Andersson, Elofsson, Rossner, & Unden, 2005). In her doctoral dissertation, Konrad measured WLOC at the end of treatment and at post-treatment follow up and found a more internalized weight locus of control to be associated with weight loss maintenance success (Konrad, 2007). Change in WLOC is not discussed. In another doctoral dissertation, WLOC is measured at baseline and controlled for in regressions, but beyond that is not discussed with regard to treatment outcome (Genugten, Empelen, & Oenema, 2011). On the other hand, some studies found no relationship between WLOC and weight loss (Elfhag & Rossner, 2010). One study found increases in internality for participants that originally ranked external on the WLOC over the course of a behavioral program, suggesting that WLOC scores may be amenable to change with intervention (Coit, Carels, Clayton, & Oernig, 2007). Additionally, the test-retest reliability of the WLOC scale is significant, but fairly weak (Saltzer, 1982), suggesting this construct can change with time.

Self-Mastery

A 7-item questionnaire, where the response to each item is based upon a four point scale, was developed as part of an effort to understand life stressors (Pearlin & Schooler, 1978). The concept of self-mastery is defined as the "extent to which one regards one's life-chances as being under one's own control in contrast to being fatalistically ruled" (Pearlin & Schooler, 1978:5). This scale is also directed toward a locus of control – whether the individual is in control of their behaviors and life events or the environment controls these topics. The self-mastery scale has been used more widely in the literature (US Department of Health and Human Services) than the WLOC scale, so it can be used comparatively with other studies in a more general sense, whereas the WLOC scale is directed to measure perceived control in one area. It is also of interest the extent this predicted increase in sense of control over body weight translates to perceived control in more general areas of life, which is another reason to include this scale. The Macarthur foundation (Seeman, 2008) describes Pearlin & Schoolers' Self Mastery scale (1978) as possibly the most widely used in measuring this construct.

Though Pearlin & Schooler's Self Mastery Scale has been cited over 5,000 times in the literature, few articles address measured body weight change and mastery. Mastery is a more global concept, not weight-specific, so it makes sense that few articles are applicable to this study. In 2007, Roberts and colleagues measured mastery and weight at the beginning and end of a 3-month period in a sample of middle aged women with normal BMIs to start (25.2 kg/m^2 on average – even though this is technically overweight for women who have probably had children and have been aging, this is close enough to normal weight) (Roberts, Troop, Connan, Treasure, & Campbell, 2007). Average within participant self mastery significantly decreased over the study period (group mean changed from 21.3 at baseline to 20.5 at endpoint), indicating a decrease in feelings of control over life circumstances. The authors grouped participants into categories of those that maintained their weight, lost weight, and gained weight. Mastery measured at baseline was not a significant predictor of weight change category ($p = 0.20$). Change in mastery borderline significance ($p=0.06$) predicted weight change category, with those that lost weight slightly increasing in mastery (+0.32±1.57), those that maintained their weight slightly decreasing in mastery (-0.75±2.26), and those that gained weight decreasing in mastery twice the amount compared to those that maintained their weight (-1.25±2.65) (Roberts et al., 2007).

In another study, researchers fed college students considerably more than they needed for a month and limited activity to induce weight gain and measured mastery (Ernersson, Frisman, Frostell, Nystrom, & Lindstrom, 2010). Ernersson and colleagues found a significant ($p = 0.02$) decrease in mastery of about 1.7 points (this scale was described as being a measure of 'coping ability') and this change was significantly different than the lack of change observed in the control group ($p =0.03$). Six and 12 months after the intervention, the intervention group's values returned to what they were before the weight gain.

Quality of Life: SF-36

The Medical Outcomes Study Short-Form Health Survey (SF-36) was developed phenomenologically, with the assertion that the perceptions of the patient are the patient's reality (Ware & Sherbourne, 1992). The SF-36 measures two facets of quality of life: physical health (measured by the four concepts: physical functioning, role limitations due to physical problems, bodily pain, and general health perceptions) and mental health (measured by four concepts: vitality, social functioning, role limitations due to emotional problems, and mental health). Thirty-six items are proposed in likert-scale format. Though between-person differences can be expected for subscales at a specified point in time, the within-person change in rating over time is the dependent variable of interest. The SF-36 was selected due to its thoughtful development, rigorous testing (Mchorney, Ware, & Raczek, 1993; Mchorney, Ware, Lu, & Sherbourne, 1994) and its exposure in the literature (almost 4,000 citations to date).

Many studies examining weight loss have included the SF-36 as one of their survey instruments. Because of the widespread use of the SF-36, it is important to define the boundaries for which studies will be included and interpreted with the results of the study being presented. Because this study is concerned with intra-individual changes in quality of life and their association with changes in weight, cross-sectional analyses reporting on associations between weight and quality of life (e.g. (Cameron et al., 2012; Doll, Petersen, & Stewart-Brown, 2000; Korhonen, Seppala, Jarvenpaa, & Kautiainen, 2013)) are not included for comparison with this study. Similarly, many studies divide participants into groups based on BMI and compare average quality of life scores by group, generally finding lower scores with higher BMI group (Cameron et al., 2012; Ni et al., 2004). Those focusing on populations different from the population of mostly white women studied here, for example African Americans (Hope, Kumanyika, Shults, & Holmes, 2010) due to the small percentage in our sample (6 out of 144). In addition, an observational study design was used to assess the relationship between BMI and quality of life cross sectionally and prospectively (Cameron et al., 2012). Cameron and colleagues did find a relationship between increases in BMI and decreases in quality of life related to health; however, this is really the opposite of the relationship of interest to this study and does not speak to the relationship between voluntary weight loss and change in quality of life.

One notable study used the seldom used RAND-36 survey (questions identical to SF-36, but different scoring algorithms which make two of the eight subscales noncomperable) (Kaukua, Pekkarinen, Sane, & Mustajoki, 2003). Since the scoring algorithms differ, direct comparison is not possible, but trends discussed due to similar patterns found in another study (Blissmer et al., 2006). Kaukua and colleagues (2003) found that though all scores increased during the weight loss program period, all decreased from their highest point 1 year and 2 years following the program. The only subscale that remained significantly higher than baseline 2 years after the program was Physical Functioning. The authors also found that most quality of life subscales did not show a favorable increase above baseline except at the 10% or more weight loss level both for physical scales (except physical functioning) and mental scales (Kaukua et al., 2003).

Behavioral interventions have been able to produce significant within-subject changes in subscales of the SF-36 in a 12 week period (Foster et al., 2009; Rippe et al., 1998), in a 13 week period (Fontaine, Barofsky, Bartlett, Franckowiak, & Andersen, 2004), and in a 6 month period (Martin, Church, Thompson, Earnest, & Blair, 2009). Generally, the physical but not mental components of quality of life show significant associations with weight loss, with the exception of vitality. Physical functioning, general health, and vitality seem to be the constructs repeatedly showing a relationship with weight change. Only one study observed a significant change in mental health: Rippe and colleagues (1998) found that perceptions of physical function, vitality, and mental health changed significantly in the group of 40 women randomly assigned to a weight watchers program, while changes in the control group were not significant over the 12 weeks of the study (Rippe et al., 1998). However, the Weight Watchers program involved exercise and weekly meetings; thus it is unclear whether the weight loss, or the components of the intervention, or a combination of the two, affected mental health. This confounding issue is especially important as it has been shown that exercise alone, regardless of weight loss, can produce significant changes in quality of life in women (Martin et al., 2009). Additionally, these significant changes may have been transient. Studies analyzing changes over a longer period of time (e.g. Blissmer et al., 2006; Fontaine et al., 2004) found that subscales that initially changed after the intervention did not necessarily keep this change at one or two years follow up. In 2004, Fontaine and colleagues published results on a sample of 32 that was 60% female and 84% white (Fontaine et al., 2004). The SF-36 was used at the end of a 13 week program and one year after the end of the program. Two subscales, general health and vitality, maintained their change from the weight loss program after a year. Interestingly, the general health and vitality change was maintained regardless of if the participants regained weight. In another study, Blissmer et al (2006) studied a sample of 144 that was 78% female and measured quality of life before and after a 6 month lifestyle modification program for weight loss, and at 12 and 24 months since baseline measurements were taken. Physical Functioning and General Health increased significantly following the intervention and remained changed 12 months since the start of the study. Two years after the study start, only Physical Functioning remained significantly changed ($p < 0.05$). This replicates the finding discussed previously (Kaukua, et al., 2003). For the mental health subscales, Vitality and Mental health significantly increased and remained increased through 24-months.

Others have not found relationship between weight loss and change in quality of life. Ni Mhurchu et al. (2004) did not find a significant relationship between change in body weight over 6 months and the physical component score (Ni et al., 2004). Conservative analyses were done following intention to treat analysis and Quality of Life scores were able to be calculated for less than 2/3 of the sample at follow up, and the authors reported using the last observation carried forward (LOCF) method for missing data. Though this would weaken any potential effect, an analysis was also done for participants with complete data and no relationship was observed. Individual subscales' relationship with 6-month change in weight are not reported, nor is mental composite score. The authors posited that the small number of participants losing 5% of their weight over the study period for a reason that a relationship was not found, as other studies citing relationships between weight loss and change in quality of life show more than double that amount of weight change (e.g. (Kaukua et al., 2003)).

Analysis

To assess the contribution of psychological and demographic factors in the relationship between treatment and weight change over time, variables were tested as main effects, and interactions with time and treatment in mixed models. Appendix 3.1 displays the p-values for the variable in each situation.

To answer the specific question of whether self-weighing contributes to a deterioration in psychological factors, the specific term of interest is the psychological factor's interaction with treatment group, or the t-test comparing the change in psychological factor over the course of a year by treatment group ('change differently by treatment group?'). However, if a higher order interaction (triple interaction) is observed, it is not appropriate to assess the interaction between the psychological variable and treatment group alone.

Results & Discussion

Baseline individual characteristics and dieting history

In general, baseline individual characteristics and dieting history did not explain a significant amount of the variability in the change in weight over time. Any relationships in the tables that did reach statistically significant levels ($p<0.05$) were probably due to chance because of the number of comparisons made ($n = 32$).

The control and the experimental group were significantly different for the change score in weight; experimental group participants lost more weight than control group participants. In addition, the proportion of participants allowing the Principal

Investigator to use quotes from email communications was significantly different between groups, with experimental participants allowing this more than control participants. The Principal Investigator contacted participants when they emailed communicating information about their weight journey. Upon realizing the potential utility of these email communications, an amendment was submitted and approved by the Institutional Review Board for the Principal Investigator to ask for permission to anonymously use quotes from emails on a case by case basis. Significantly more ($p = 0.011$) of the experimental participants were asked than the control participants. This is likely due to the fact that the experimental participants were in contact with the research team more frequently and thus more likely to email the Principal Investigator or research team email account with information about why their weight had been changing, why they had not been weighing, etc.

When comparing males and females, significant differences were found. Tables of gender comparisons are presented in Appendix 2.4. There was a significant ($p = 0.009$) difference in the self-reported number of times men (3.0 ± 1.2) and women (3.7 ± 1.4) tried to lose weight in their lifetime. Similarly, there was a significant ($p = 0.03$) difference in self-reported dieting attempts, with women more likely to say that they had attempted to diet. Of those that said they were on a diet however, there were no significant differences in the number of months out of the past year that they had been on a diet. Nor was there a difference between men and women regarding if they were currently on a diet or self-reported success of past dieting attempts.

There was a significant ($p = 0.02$) difference in how in control men and women felt of their weight. Men gave themselves a score on average of 5.3 ± 2 out of a possible 10 points while women reported lower, 4.3 ± 2. Men felt an entire point more in control of their weight on average than women. There were also significant ($p < 0.05$) differences in Restraint (men = 8.3 ± 3.3; women = 10.3 ± 3.8), Disinhibition (men = 8.6 ± 3.7; women = 10.1 ± 3.2) , the proportion of individuals classified as high restraint-high disinhibition (men = 0.18 ± 0.39; women = 0.37 ± 0.48) and low-restraint-low-disinhibition (men = 0.39 ± 0.50; women = 0.17 ± 0.38), flexible (men = 2.3 ± 1.1; women = 3.1 ± 1.6) and rigid (men = 2.5 ± 1.6; women = 3.3 ± 1.7) control of eating, weight locus of control measured at time 2 and time 3, wave (when the participant started the study), and weight at time 1, 2, and 3.

Measuring perceived control over weight

Control Question: getting right to the point

Appendix 3.1 shows the p-values associated with the variable assessing perceived control over weight when comparing the experimental group over the first year with the control group over the first year. Since the triple interaction is significant, the relationship is explored at this level.

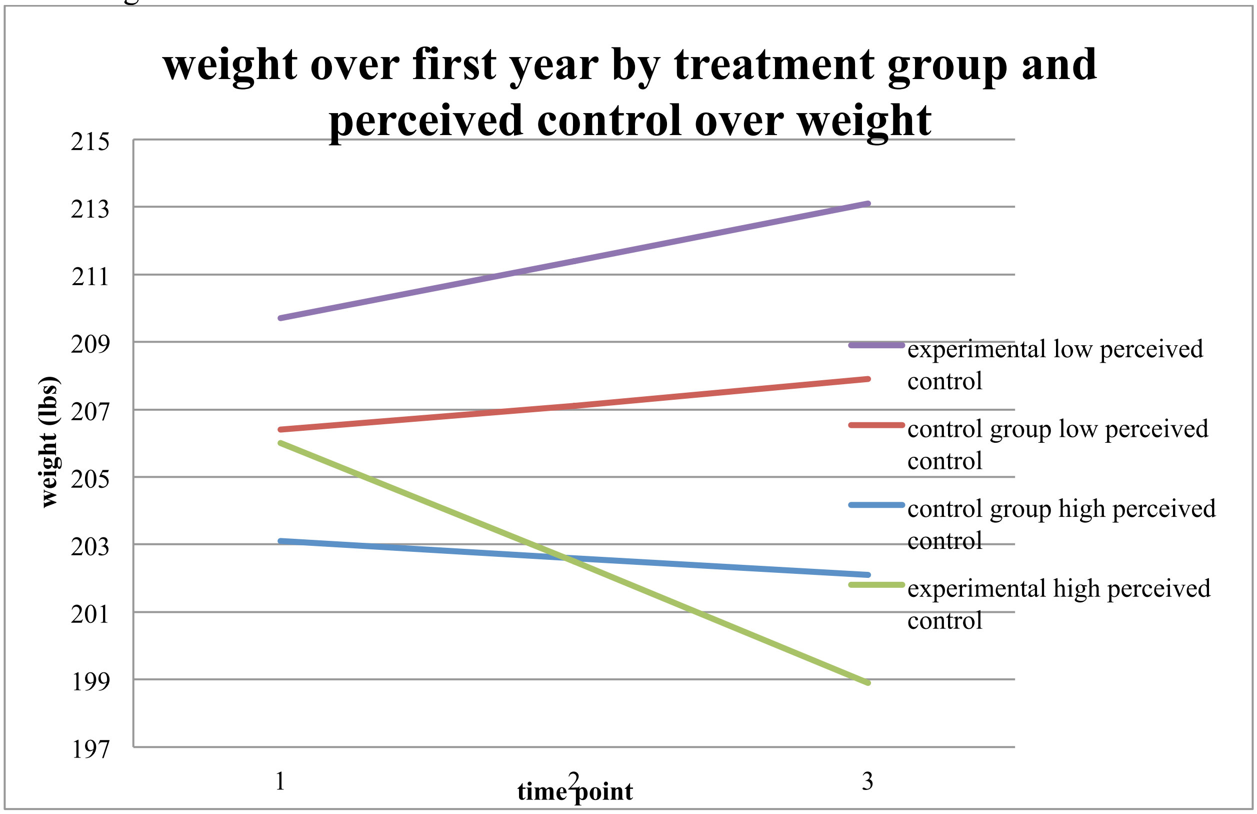
Table 3.1 Significance values for perceived control over weight

Variable	Change over the first year? 1	Change differently by tx group? 2	P value main effect3	P value interaction with randcode4	P value interaction with timept5	P value triple interaction6
Control	0.000	0.224	0.000	0.030	0.000	0.030

1 Difference between end of first year and baseline sig diff from zero for entire sample
2 Sig difference in change in this variable over first year depending upon gender (independent t-test using wide format change value calculated grouping by treatment group)
3 p-value of the main effect when the variable is added to the MIXED model as a main effect
4 p-value of the interaction term when added as treatment group*variable interaction (and main effect)
5 p-value of the interaction term when added as time point*variable interaction (and main effect)
6 p-value of the three-way interaction when added as a treatment group*time point*variable interaction (with both 2-way interactions and main effects)

The following graph was derived from obtaining estimated marginal means (mean for control for all time points is 5.0 and SD is 2.2; one SD below mean is 2.8 , and one SD above mean is control=7.2.). The syntax for obtaining these estimates can be found in appendix 3.2.

Figure 3.1



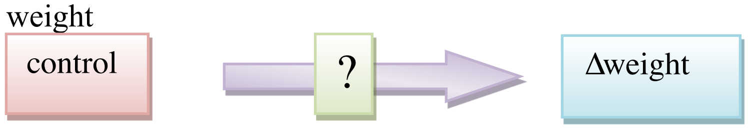
Participants with varying levels of perceived control over their weight's weight trajectories over one year depending on treatment group

There is a difference in mean body weight over the first year of the study depending upon treatment group (control or experimental) and perceived control score (high or low). A high control score was defined as one standard deviation above the sample's mean and a low control score was defined as on standard deviation below the sample's mean.

As shown in the line graph above, it seems that those with high perceived control over their weight, both in the experimental and control group, lose weight with time. However, those in the experimental group with high perceived control over their weight appear to lose weight at a faster rate and lose more than those in the control group with high perceived control over their weight. On the other hand, participants with low perceived control over their weight gained weight over the first year of the study regardless of treatment group. Interestingly, it appears that those in the experimental group that had a low perception of control over their weight gained weight at a slightly faster rate than those in the control group. This could mean that the CTM serves to exacerbate whatever beliefs an individual already holds about their weight – if they believe they are in control over their weight, the technique of weighing themselves and seeing a graph reinforces this belief, whereas those that do not believe they have control over their weight do not see the connection between their daily weights and their behaviors. Alternatively, it could be that those who believe they have control over their weight are more likely to follow the directions of weighing themselves and inputting their weights on the website because their beliefs are in alignment with the purpose of the CTM, whereas those with low perceived control do not believe that the CTM will work so either do not give it a chance or go into it with the mindset that it won't work for them, following a self-fulfilling prophecy.

This relationship insinuates that the level of weight locus of control is preceding weight loss and driving that relationship.

Figure 3.2 Possible relationship between perceived control over weight and change in weight



On the other hand, it is possible that the change in body weight could result in a change in control.

Figure 3.3 Possible relationship between change in weight and change in perceived control over weight

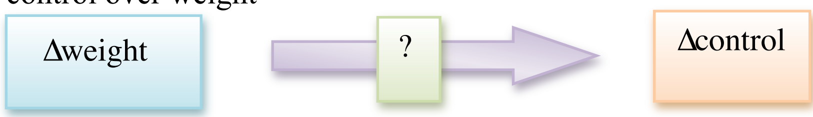
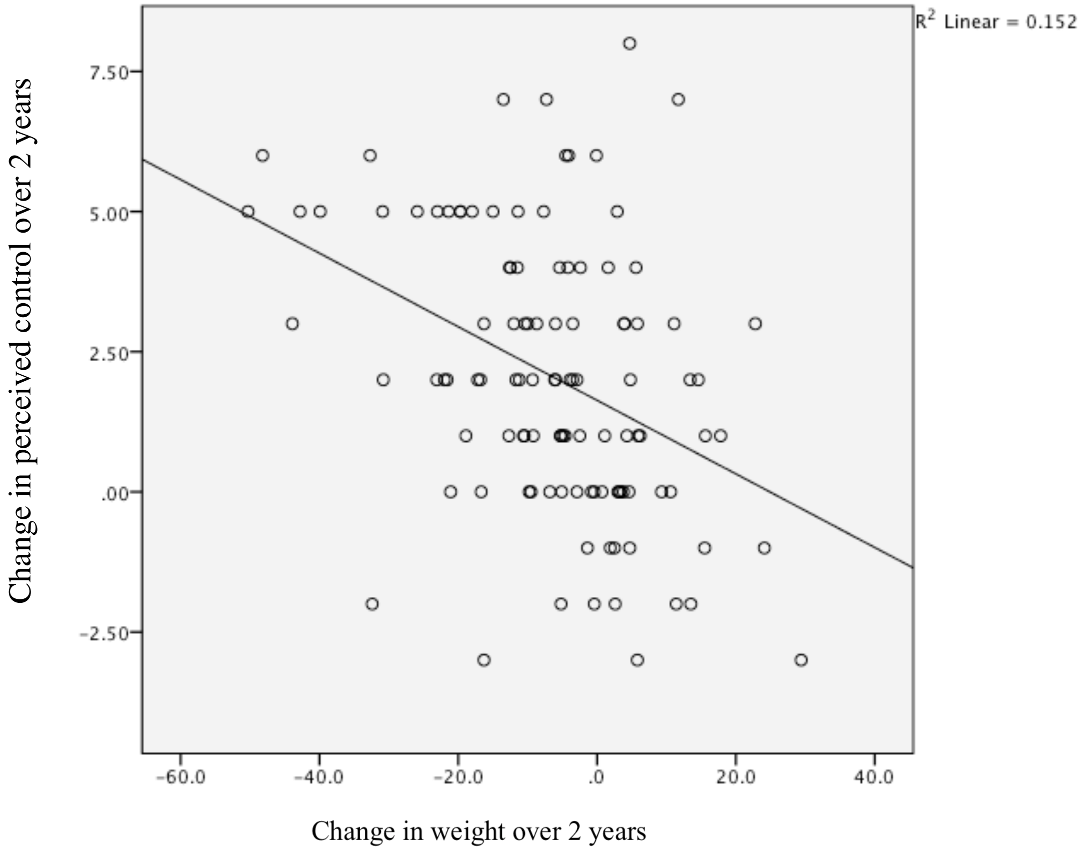


Figure 3.4 shows the change in perceived control as a function of weight loss across the full two years of the study. The change in weight over 2 years is significant in explaining some of the variability in the change in perceived control over weight over 2 years. The R squared value is 0.152, meaning that the change in weight can explain about 15% of the variability in change in perceived control over weight. The slope of the line graphed through the graph is significantly different from zero ($p = 0.000$).

Figure 3.4

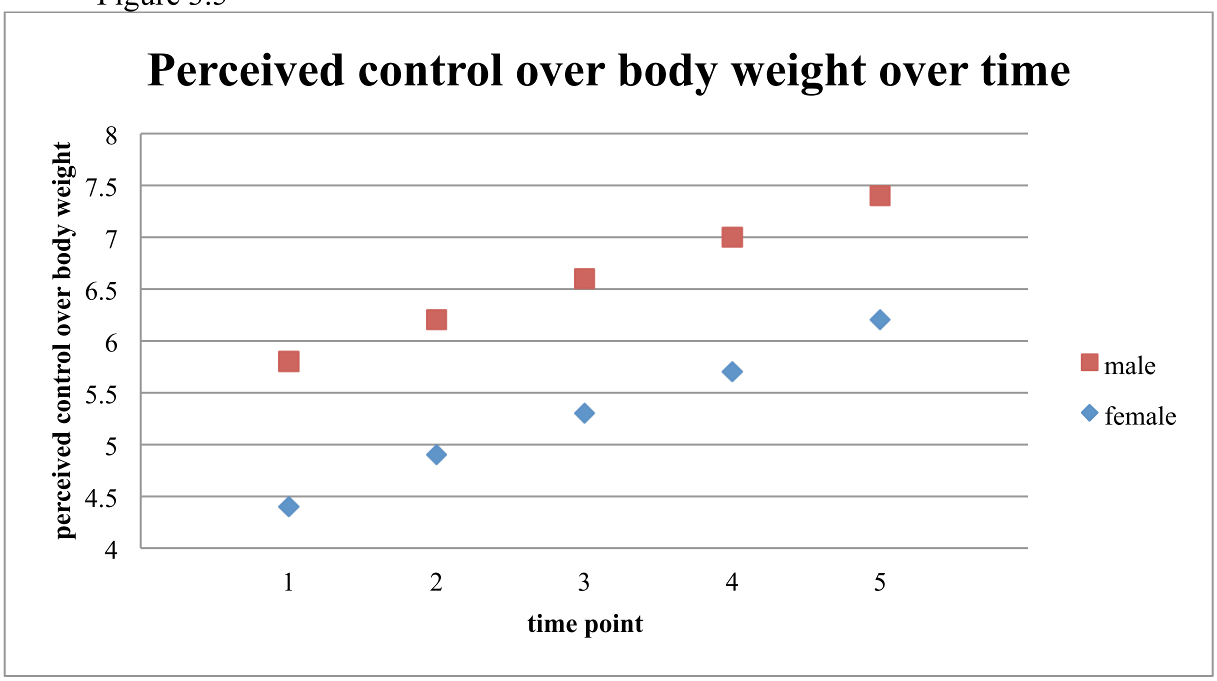


Graph displaying relationship between change in weight over 2 years and change in perceived control over weight over 2 years

Another way to examine the change in perceived control over weight over time would be to run a random coefficient random slope model with control as the dependent variable for those in the treatment group (here we are not comparing the change in perceived control between groups, we are looking to see if there is a consistent change in each individual's change in perceived control over time while using the CTM). In modeling the change in perceived control over time during treatment, time is significant for both males ($p = 0.016$) and females ($p = 0.000$).

The following two graphs display different ways of illustrating the relationship between perceived control of body weight and time. The first graph (Figure 3.5) using the data from the mixed model forces a linear relationship between the variables. However, this linear relationship is derived from averaging each participant's individual linear relationship between time and control score. Thus, it is a more appropriate way to describe the data as we are interested in individual's change over time. The second graph (Figure 3.6) is problematic because increases or decreases may not actually represent actual changes, but could indicate people with high or low perceived control dropping out of the study.

Figure 3.5

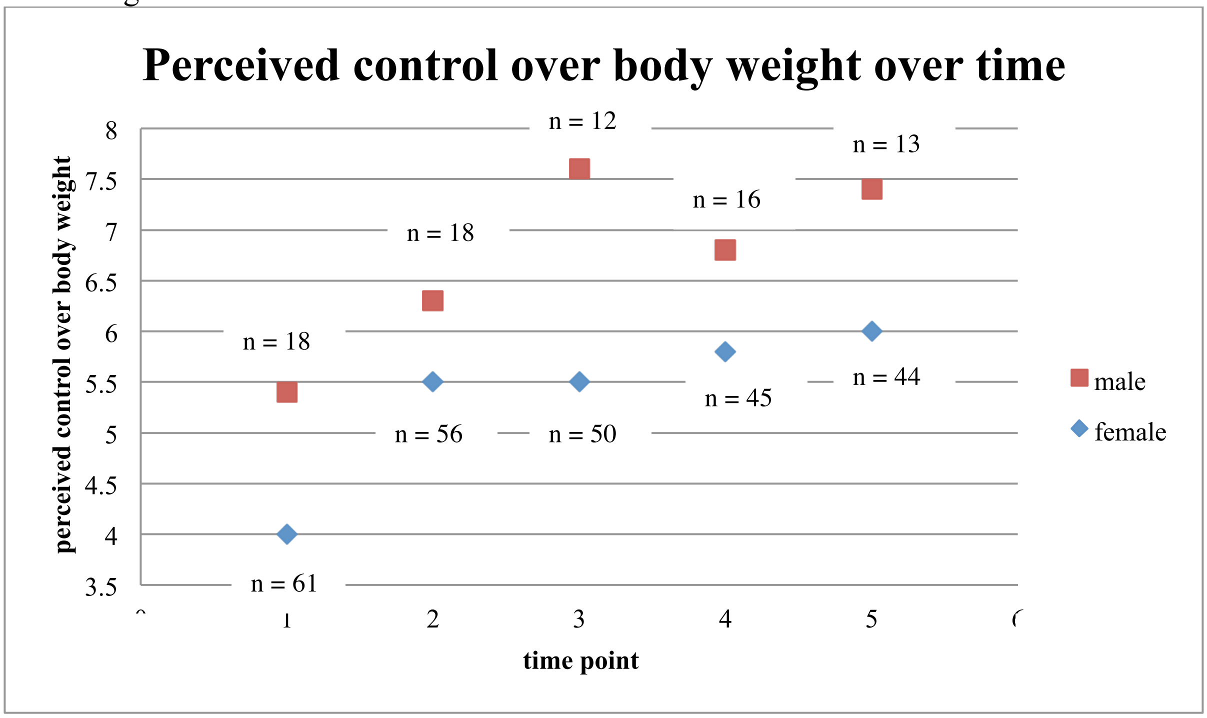


Perceived control over body weight over time by gender using estimated marginal means from a mixed model (experimental participants only)

Another way to visually display this relationship would be to graph average perceived control score at each time point for males and females, as shown in Figure

3.6, which produces a slightly different visual which is useful for displaying the difference between this method of analysis and the mixed model:

Figure 3.6



Perceived control over body weight over time by gender using average perceived control over weight at each time point (experimental participants only)

This study cannot establish the directionality of the relationship between perceived control over weight and change in weight or change in weight and change in perceived control over weight. These options are possibilities.

Weight Locus of Control: a weight-specific survey

As shown in appendix 3.1 when comparing the experimental group over the first year with the control group over the first year, there is a significant interaction between weight locus of control, treatment group, and time (Table 3.2).

Table 3.2 Significance values for weight locus of control

Variable	Change over the first year? [1]	Change differently by tx group? [2]	P value main effect[3]	P value interaction with randcode[4]	P value interaction with timept[5]	P value triple interaction[6]
WLOC	0.310	0.692	0.053	0.570	0.017	0.013

[1] Difference between end of first year and baseline sig diff from zero for entire sample

[2] Sig difference in change in this variable over first year depending upon gender (independent t-test using wide format change value calculated grouping by treatment group)

[3] p-value of the main effect when the variable is added to the MIXED model as a main effect

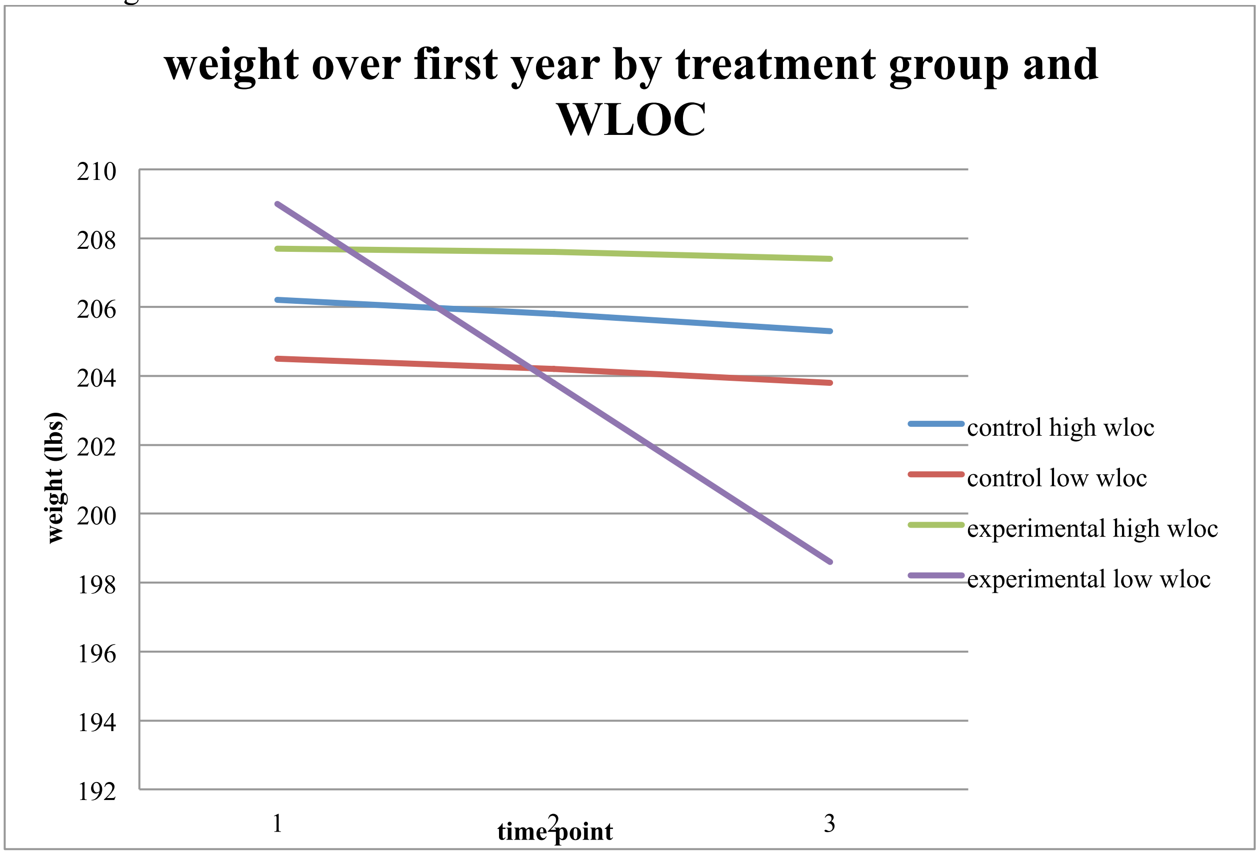
[4] p-value of the interaction term when added as treatment group*variable interaction (and main effect)

[5] p-value of the interaction term when added as time point*variable interaction (and main effect)

[6] p-value of the three-way interaction when added as a treatment group * time point *variable interaction (with both 2-way interactions and main effects)

Figure 3.7 was derived from obtaining estimated marginal means (mean for WLOC for all timepoints is 8.85 and SD is 2.85; one SD below mean is 6.0 , and one SD above mean is WLOC=11.7). The syntax for obtaining these estimates can be found in appendix 3.2.

Figure 3.7



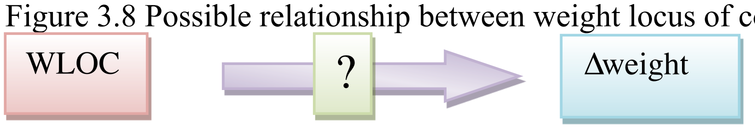
Participants with varying levels of weight locus of controls' weight trajectories over one year depending on treatment group

There is a difference in the change in weight over the first year of the study depending upon treatment group (control or experimental) and weight locus of control (WLOC) score (high or low). A high WLOC score was defined as one standard deviation above the sample's mean and a low WLOC score was defined as on standard deviation below the sample's mean.

It appears that participants in the control group's weight evolves similarly regardless of level of WLOC in Figure 3.7. In addition, for participants in the experimental group that fall one standard deviation above the mean on WLOC (more externally controlled), weight changes similarly to the control group. On the other hand, participants in the experimental group with WLOC about one standard deviation below the mean (more internally controlled) have a much more drastic weight decrease over the first year suggesting that people who believe that their weight is more under their own control as opposed to controlled by external factors would have greater success with weight loss using the CTM. Since the CTM is theorized to provide the individual with evidence that they can control their weight, it would be easier to convince people that already believe that they have some control over their weight.

This relationship insinuates that the level of weight locus of control is preceding weight loss and driving that relationship.

Figure 3.8 Possible relationship between weight locus of control and change in weight



On the other hand, it is possible that the change in body weight could result in a change in weight locus of control.

Figure 3.9 Possible relationship between change in weight and change in weight locus of control

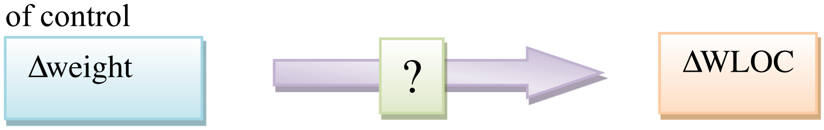
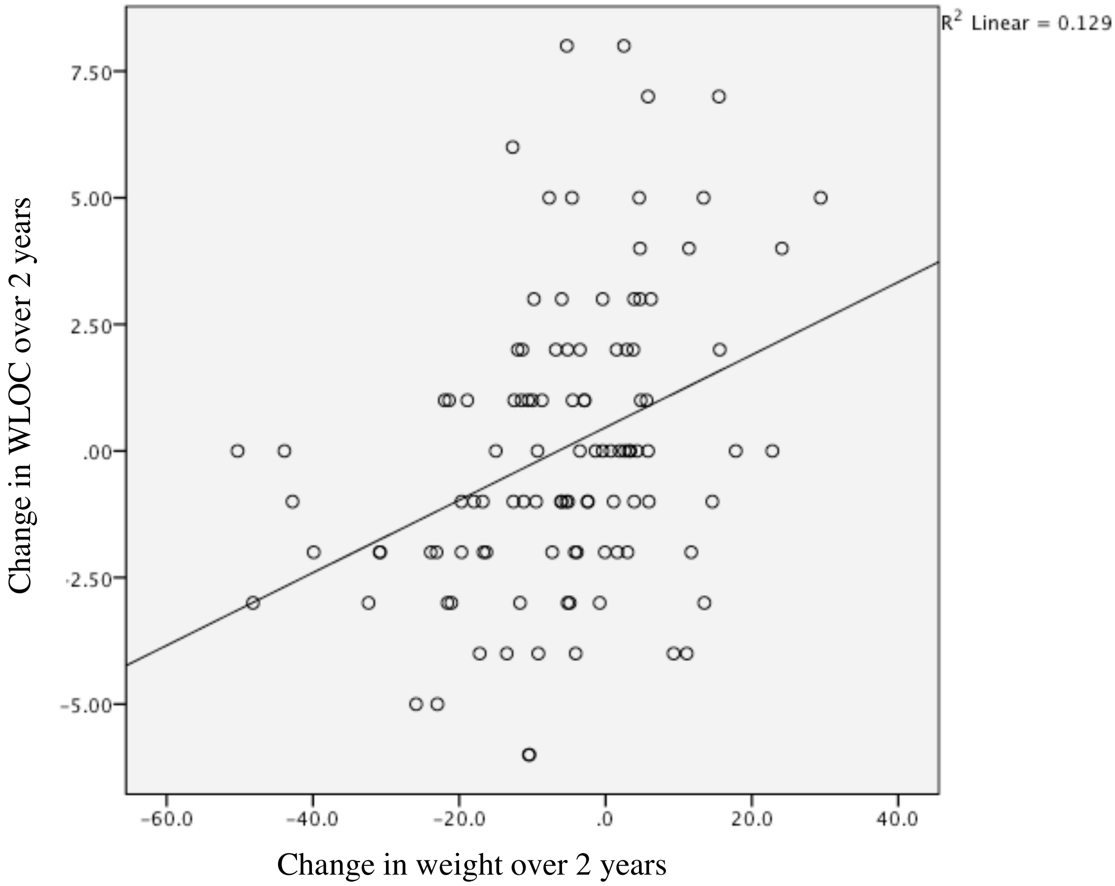


Figure 3.10 displays the change in WLOC as a function of weight loss across the full two years of the study. The change in weight over 2 years is significant in explaining some of the variability in the change in weight locus of control over 2 years. The R squared value is 0.129, meaning that the change in weight can explain about 13% of the variability in change in weight locus of control.

Figure 3.10



Graph displaying relationship between change in weight locus of control over 2 years and change in weight over 2 years

Another way to examine the change in WLOC over time would be to run a random coefficient random slope model with WLOC as the dependent variable for those in the treatment group (this is not comparing the change in WLOC between groups, to see if there is a consistent change in each individual's change in weight locus of control over time while using the CTM). In modeling the change of WLOC over time during treatment, time was not significant. This was done for the experimental group over 2 years. Combining the first year of the experimental group with the second year of the controls (former controls' first year in the experimental treatment) for more power, time was still not a significant predictor of WLOC. Finally, analyses were done separately by gender, and time was more significant for males ($p = 0.14$; estimated slope of WLOC = -0.3635) as compared to females ($p = 0.604$; estimated slope of WLOC = -0.0722). Although these terms suggest that there is not a significant change in WLOC during treatment (or our sample size is not large enough to detect this change), the slope estimates are both negative, indicating a decrease in WLOC with time. Since lower scores on the WLOC are more internal weight control as opposed to higher scores meaning individuals feel their weight to be determined by external factors, this relationship is in the direction that we would propose, but fails to reach statistical significance.

This study cannot establish the directionality of the relationship between weight locus of control and change in weight or change in weight and change in weight locus of control. These options are possibilities.

Self Mastery: a broad view of control

When comparing the experimental group over the first year with the control group over the first year, participant’s score on the self mastery scale is not a significant predictor or interaction with the variables of interest (treatment group and or time) as shown in Appendix 3.1 and Table 3.3.

Table 3.3 Significance values for self mastery

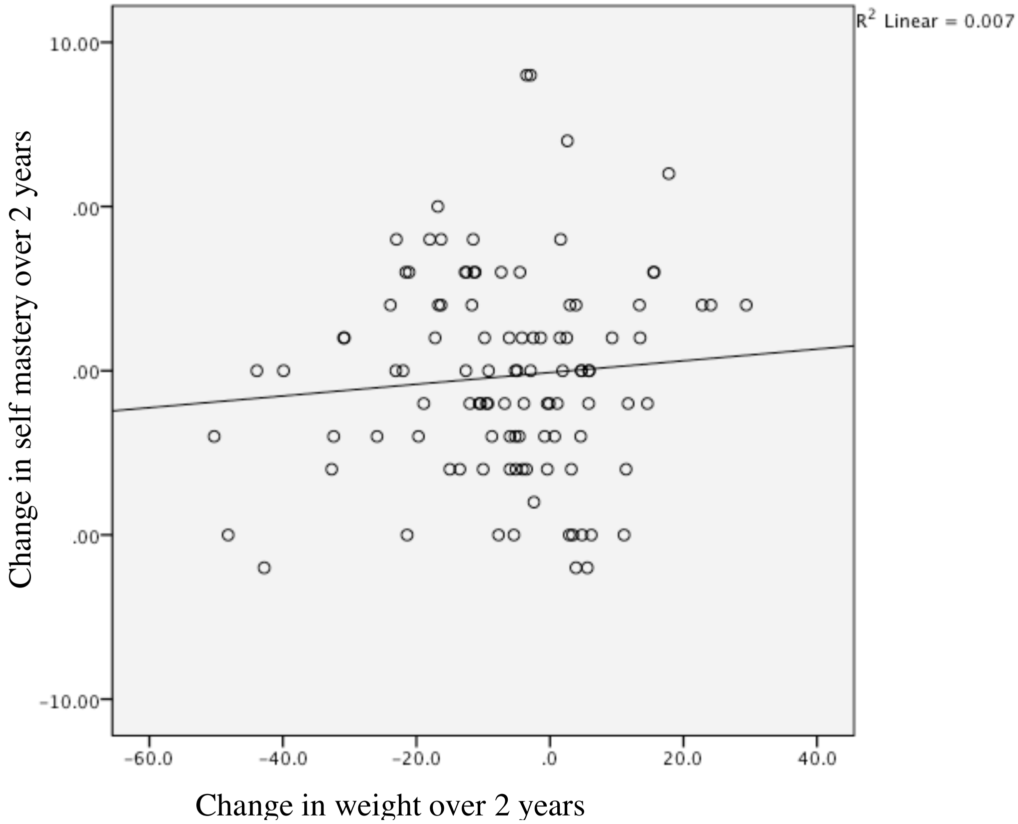
Variable	Change over the first year? 1	Change differently by tx group? 2	P value main effect3	P value interaction with randcode4	P value interaction with timept5	P value triple interaction6
SMastery	0.408	0.690	0.397	0.122	0.946	0.274

1 Difference between end of first year and baseline sig diff from zero for entire sample
2 Sig difference in change in this variable over first year depending upon gender (independent t-test using wide format change value calculated grouping by treatment group)
3 p-value of the main effect when the variable is added to the MIXED model as a main effect
4 p-value of the interaction term when added as treatment group*variable interaction (and main effect)
5 p-value of the interaction term when added as time point*variable interaction (and main effect)
6 p-value of the three-way interaction when added as a treatment group * time point *variable interaction (with both 2-way interactions and main effects)

Figure 3.11 displays change in mastery as a function of weight loss across the full two years of the study. The change in weight over 2 years is not significant in explaining some of the variability in the change in weight locus of control over 2 years. The R squared value is 0.007, meaning that the change in weight can explain less than 1% of the variability in change in mastery. The p-value for the line fit to this graph is >0.05, indicating that the slope of the line is not significantly different from zero.

Baseline perceived control over body weight was significantly negatively associated with baseline WLOC (r = -0.23; p = 0.07) and baseline self mastery (r = -0.20; p = 0.021). Basline WLOC and baseline self mastery were significantly positively associated (r = 0.23; p = 0.007).

Figure 3.11



Graph displaying relationship between change in self mastery over 2 years and change in weight over 2 years

Finally, when running a random slope and intercept coefficient model to assess changes in mastery over time of those using the treatment, time was not significant ($p > 0.05$).

Quality of Life

None of the 8 subscales of quality of life as measured by the SF-36 were involved in a statistically significant interaction with time and treatment group. General Health and Vitality were marginally significant in their interaction with treatment group and time (p values = 0.077 and 0.076, respectively). Since the triple interactions are not significant, it is appropriate to evaluate effects at the interaction level. Role Physical subscale was borderline significant ($p = 0.06$) in interacting with time, suggesting that there was a trend in the overall sample's change in how they viewed the physical aspect of their roles over time. The only subscale that had a significant ($p = 0.037$) interaction with treatment group was Vitality, indicating that the change in weight over time differed depending upon which group participants were randomized to and their level of vitality. Role Emotional and the Mental Composite Score were borderline significant as interacting with treatment group (p values = 0.052 and 0.071, respectively).

In terms of main effects, all four of the physical health subscales explained a significant amount of the variability of weight. Not surprisingly, this was reflected in the Physical Composite Score. Of the mental health subscales, only Role Emotional explained a significant amount of the variability in weight.

When performing t-tests to evaluate a significant change in score over the first year of the study, General Health and Vitality changed significantly ($p = 0.003$ and 0.008, respectively).

Three Factor Eating Questionnaire: Restraint, Hunger, and Disinhibition

Table 3.4 displays Pearson bivariate correlations between baseline dietary restraint, hunger, and disinhibition and weight change over 2 years and changes in restraint, hunger, and disinhibition and weight change over 2 years.

Table 3.4 Correlations between Three Factor Eating Questionnaire subscales and change in subscales over 2 years and change in weight over 2 years

		Restraint	ΔRestraint	Hunger	ΔHunger	Disinhibition	ΔDisinhibition	2yr Δ weight
Restraint	Pearson Correlation	1	-.43**	.19*	-.03	.14	-.06	-.02
	Sig. (2-tailed)		.000	.024	.768	.094	.562	.860
	N	146	112	145	111	146	112	118
ΔRestraint	Pearson Correlation	-.43**	1	.05	-.24*	-.11	-.20*	-.32**
	Sig. (2-tailed)	.000		.610	.011	.247	.031	.001
	N	112	112	111	111	112	112	109
Hunger	Pearson Correlation	.19*	.05	1	-.30**	.35**	-.00	-.01
	Sig. (2-tailed)	.024	.610		.001	.000	.965	.933
	N	145	111	145	111	145	111	117
ΔHunger	Pearson Correlation	-.03	-.24*	-.30**	1	-.08	.38**	.24*
	Sig. (2-tailed)	.768	.011	.001		.426	.000	.013
	N	111	111	111	111	111	111	108
Disinhibition	Pearson Correlation	.14	-.11	.35**	-.08	1	-.39**	-.01
	Sig. (2-tailed)	.094	.247	.000	.426		.000	.906
	N	146	112	145	111	146	112	118
ΔDisinhibition	Pearson Correlation	-.06	-.20*	-.00	.38**	-.39**	1	.34**
	Sig. (2-tailed)	.562	.031	.965	.000	.000		.000
	N	112	112	111	111	112	112	109
2 yr Δ weight	Pearson Correlation	-.02	-.32**	-.008	.24*	-.01	.34**	1

	Sig. (2-tailed)	.860	.001	.933	.013	.906	.000	
	N	118	109	117	108	118	109	120

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Although baseline restraint, hunger, and disinhibition were not significantly associated with change in weight over the two years of the study, changes in all three had a significant ($p <0.05$) association with change in weight. For restraint, the relationship was negative ($r = -0.32$), while for hunger and disinhibition, the relationship was positive ($r = 0.24$ and 0.34 respectively).

In summary, it appears that there are consistent associative relationships between weight loss and changes in several psychological variables, in this study, and others. This study observed that perceived control over weight and weight locus of control were key correlates of weight change over time in the experimental condition, using daily self-weighing and visual feedback. Those that perceived their weight to be in their control, and those that perceived to be in control of their weight as compared to having external factors control their weight, were more successful in losing weight with the intervention. A more global measure of control, Self Mastery, did not have a relationship with weight over time. This could be due to lack of power to determine a statistically significant effect, but is more likely due to minimal weight changes not being pervasive enough to affect a global sense of control over life as many other factors contribute to this variable.

Findings did not support negative shifts in psychological variables measured in individuals directed to self-weigh compared with individuals not directed to self-weigh. There could be several reasons for failure to find this relationship. It is possible that the present study was not adequately powered to detect these differences, as weight changes were relatively small. However, based on published findings, this is not likely. As discussed, past findings are mixed in terms of positive or negative psychological associations or changes when individuals frequently weigh themselves. Heterogeneity of participant populations is a possible contributor to the ambiguity of this relationship. When stratifying by age, it seems that self-weighing in adolescents or younger adults (about 20 years old) is found to be associated with detrimental attitudes and health behaviors (Neumark-Sztainer et al., 2006; Ogden & Whyman, 1997; Quick et al., 2012; Quick et al., 2013), whereas in adults that could benefit from increased weight control and use self-weighing to assist with weight loss, adverse psychological changes are not found or psychological changes are beneficial (Gokee LaRose, Tate, Gorin, & Wing, 2010; Wing et al., 2007). Future research may use study designs that allow for stronger inference into direction of causation and consider the conceptual underpinnings of the proposed negative relationship between self-weighing and psychological state. Two conditions need to be satisfied for this to occur: (1) the individual must be pre-occupied with their weight, to the extent that this pre-occupation spreads to other senses of their psyche and (2) the individual must be dissatisfied with their current weight in comparison to an idealized weight expectation, which may or may not be healthful. If one condition is satisfied, but the other is not, negative psychological outcomes would not necessarily be expected.

The findings discussed are consistent with those published in the literature. Participants scoring lower on Weight Locus of Control, which designates feeling personally in control of weight as opposed to external factors (like genetics, or family) determining weight, were more successful in losing weight. Konrad found that those with more internal WLOC were more successful with weight loss maintenance (Konrad, 2007), and the present study found that those with a more internal WLOC were more successful in using an intervention that was based on the individual exploring and figuring out what works best for them. The present study did not find an internalization of weight locus of control over time, in opposition to the findings of Coit et al. (2007). Coit and colleagues examined 46 obese adults and found this change over a 6 month period. Because the results were published in a conference abstract, the amount of weight lost through the 6 month behavioral program is not noted. It is possible that a large degree of weight loss is necessary to modify WLOC and that the present study did not reach large enough changes in weight to show a significant change in WLOC. It is also possible that when beginning a weight loss program, changes in WLOC occur, but are transient, as was seen with several of the quality of life measures. It could be that after 6 months, WLOC values internalize, but this effect diminishes after 1 and 2 years.

Similar to Roberts (2007), Mastery was not predictive of weight change (Roberts, Troop, Connan, Treasure, & Campbell, 2007). In contrast to Roberts' findings, the present study did not find a significant change in Mastery over time. Notably, the design of Roberts and colleagues' study is prospective and observational; no intervention was used. They found that students losing weight had an increase in Mastery over 3 months, while those maintaining or gaining weight decreased in Mastery.

A major difference between the present study and prior studies of quality of life and weight change is the amount of weight lost in a given amount of time. When losing a greater amount of weight in a shorter period of time, others have found that more subscales of the SF-36 show a significant change, but that some of these disappear with time (Blissmer et al., 2006; Fontaine et al., 2004; J. Kaukua et al., 2003). The present studies' main findings concern General Health and Vitality, which are the subscales that others find relationships with weight loss as well. The relationships found in this study were borderline significant and did not tend to differ between the treatment and control group. This could be due to the relatively small amount of weight lost in this study and the fact that the control group also lost weight.

Regarding the Three Factor Eating Questionnaire subscales of cognitive restraint, hunger, and disinhibition, the present study did not find significant relationships between baseline values and weight change over 2 years. The existing literature is mixed with regards to this relationship. Some studies found significant relationships at baseline predicting weight change with restraint (Björvell et al., 1986; Savage et al., 2009), others do not (Bryant et al., 2012). An important difference between these studies is that Bryant et al. (2012) focused on exercise, and did find a relationship between baseline disinhibition and weight change. There could be distinct relationships between exercise versus caloric restriction and restraint, hunger, and disinhibition. The complexities of these relationships have not been teased apart due to the lack of studies evaluating these specific associations. The present study did find a significant relationship between the change in restraint, change in hunger, and change in disinhibition and change in weight over a 2 year period. This is an important finding because it could indicate that behavioral interventions are able to produce a shift in eating behaviors, and that this intrapersonal shift is related to weight change.

Due to design, the present study cannot determine the direction of the relationship between psychological factors and weight change. Several possibilities exist and these could be operating to differing degrees in each individual's situation. People with higher baseline scores on the psychological variable could be more open to treatment and be more successful, as seen in those with high perceived control over their weight or a more internal locus of control losing more weight with the CTM. People that successfully lose weight could improve in the psychological measures. Possible confounders of this relationship could be social interaction with study staff, exercise as a component of the intervention, or some other aspect that improves psychological factors but is not related to weight loss directly. Some aspect of the intervention could also improve psychological measures (e.g. meeting with an especially motivating counselor may increase levels of perceived control over weight) which could then lead to weight loss. The degree to which each of these situations is occurring is not able to be isolated based on study design. To the extent that these variables can be manipulated, causality could be examined. The feasibility and utility of studies directly intervening to modify psychological factors is fairly low, and the chance of adequately powered trials to be run for this purpose is not likely. The present study can only asses psychological effects to the extent of how well the measurement indices assess what they are attempting to assess, which can be assigned a number with validated and well used questionnaires, but may not be possible with single questions used to assess some characteristic. In addition, this study includes only overweight and obese adults (BMI greater than or equal to 27.0 kg/m2) that do not self-report a history of an eating disorder. Thus, the population we are attempting to generalize to is that of the overweight and obese, adult, non-eating disordered population.

Conclusion

In conclusion, this randomized trial of self-weighing and visual feedback of one's weight failed to suggest adverse psychological outcomes due to frequent self-weighing. These findings must be taken in context – study participants included adults with a BMI of greater than or equal to 27.0 kg/m2 who were not diabetic, pregnant, or reported a history of an eating disorder. It is also possible that the size of the sample studied here was not large enough to observe a statistically significant effect on psychological outcomes. This is unlikely because the psychological factors measured here moved in a favorable direction for the group administered the self-weighing intervention. Results of the present study may or may not apply to different age groups. Research suggests that in adolescents, self-weighing may not be as benign (Friend, Bauer, Madden, & Neumark-Sztainer, 2011; Neumark-Sztainer et al., 2006; Quick et al., 2012); however, studies designed to test directionality of the association between self-weighing and negative behavioral controls over eating in this population have not been done. Future research evaluating the psychological effects of self-weighing on specific racial, ethnic, gender, and age populations is warranted if the CTM strategy is to be used for public dissemination for weight control.

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APPENDIX 3.1 Syntax for including psychological variables & table of p-values

```
MIXED weight BY ID randcode WITH timept
  /CRITERIA=CIN(95) MXITER(10) MXSTEP(1) SCORING(1)
SINGULAR(0.000000000001) HCONVERGE(0, ABSOLUTE)
    LCONVERGE(0, ABSOLUTE) PCONVERGE(0.000001, ABSOLUTE)
  /FIXED=randcode timept randcode*timept | SSTYPE(3)
  /METHOD=REML
  /RANDOM INTERCEPT timept|subject(ID) COVTYPE(UN)
/PRINT solution
 /SAVE=RESID PRED.
```

Type III Tests of Fixed Effects[a]

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	147.112	4091.422	.000
randcode	1	147.112	.550	.459
timept	1	140.233	9.620	.002
randcode * timept	1	140.233	5.056	.026

a. Dependent Variable: obj Weight (lbs) .

Estimates of Fixed Effects[a]

Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Intercept	210.573466	4.399127	147.400	47.867	.000	201.879961	219.266971
[randcode=1]	-4.828536	6.508613	147.112	-.742	.459	-17.690993	8.033921
[randcode=2]	0[b]	0	.	.	.	.	.
timept	-2.595492	.666447	142.159	-3.895	.000	-3.912918	-1.278066
[randcode=1] * timept	2.181587	.970244	140.233	2.248	.026	.263390	4.099783
[randcode=2] * timept	0[b]	0	.	.	.	.	.

a. Dependent Variable: obj Weight (lbs) .
b. This parameter is set to zero because it is redundant.

Using this basic model what is each specific variable's role/relationship in the model

Variable	**Change over the first year?** [1]	**Change differently by tx group?** [2]	**P value main effect** [3]	**P value interaction with randcode** [4]	**P value interaction with timept** [5]	**P value triple interaction** [6]
Gender	N/A	N/A	0.000	0.371	0.059	0.020
Age_1	N/A	N/A	0.011	0.304	0.183	0.245
Education	N/A	N/A	0.846	0.243	0.039	0.746
Important_losewt2 (categorical) [7]	N/A	N/A	0.051	0.148	0.866	0.600
Times_losewtpastyr_contin	N/A	N/A	0.622	0.493	0.548	0.693
Times_losewtlifetime_cont	N/A	N/A	0.279	0.342	0.879	0.584
OnDiet	N/A	N/A	0.128	0.850	0.583	0.723
Dietinpast	N/A	N/A	0.572	0.682	0.705	0.929
Monthsondiet	N/A	N/A	0.475	0.646	0.410	0.633
successpastdiet	N/A	N/A	0.590	0.446	0.856	0.653
Status_dichotomized	N/A	N/A	0.902	0.537	0.142	0.346
Wave1startinseptwave2startinoct	N/A	N/A	0.434	0.801	0.640	0.791
InitialSess_dichotomized	N/A	N/A	0.489	0.296	0.348	0.884
Height_avg	N/A	N/A	0.000	0.866	0.167	0.186
Control	0.000	0.224	0.000	0.030	0.000	0.030
Restraint [8]	N/A	N/A	0.161	0.671	0.437	0.536
Hunger [8]	N/A	N/A	0.783	0.328	0.164	0.137
Disinhibition [8]	N/A	N/A	0.382	0.763	0.527	0.592
Flexiblecontrol [8]	N/A	N/A	0.021	0.890	0.663	0.804
Rigidcontrol [8]	N/A	N/A	0.311	0.743	0.424	0.268
Wloc	0.310	0.692	0.053	0.570	0.017	0.013
SMastery	0.408	0.690	0.397	0.122	0.946	0.274
SF-36: Physical Functioning (PF)	0.095	0.907	0.001	0.985	0.279	0.571
SF-36: Role Physical (RP)	0.251	0.396	0.000	0.287	0.060	0.465
SF-36: Bodily Pain (BP)	0.448	0.720	0.014	0.821	0.170	0.847
SF-36: General Health (GH)	0.003	0.898	0.000	0.174	0.110	0.077
SF-36: Vitality (VT)	0.008	0.196	0.052	0.037	0.257	0.076
SF-36: Social Functioning (SF)	0.370	0.165	0.003	0.133	0.251	0.901

SF-36: Role-Emotional (RE)	0.136	0.088	0.128	0.052	0.246	0.224
SF-36: Mental Health (MH)	0.426	0.560	0.993	0.244	0.544	0.351
SF-36: Physical Composite Score (PCS)	0.165	0.745	0.000	0.507	0.148	0.954
SF-36: Mental Composite Score (MCS)	0.222	0.145	0.520	0.071	0.546	0.308

1 Difference between end of first year and baseline sig diff from zero for entire sample
2 Sig difference in change in this variable over first year depending upon gender (independent t-test using wide format change value calculated grouping by treatment group)
3 p-value of the main effect when the variable is added to the MIXED model as a main effect
4 p-value of the interaction term when added as randcode*variable interaction (and main effect)
5 p-value of the interaction term when added as timept*variable interaction (and main effect)
6 p-value of the three-way interaction when added as a randcode*timept*variable interaction (with both 2-way interactions and main effects)
7 p-values shown are for when important_losewt2 is run as a categorical variable. When run as a continuous variable all p-values NS
8 Baseline values were used as time invariant covariates
9 N/A = not applicable (e.g. this variable does not change)

The above comparisons were done using the raw scores. What happens if using SF-36 NBS (norm-based scores)?

Variable	Change over the first year? [1]	Change differently by tx group? [2]	P value main effect [3]	P value interaction with randcode[4]	P value interaction with timept[5]	P value triple interaction [6]
SF-36: Physical Functioning (PF_NBS)	0.076	0.907	0.001	0.985	0.279	0.571
SF-36: Role Physical (RP_NBS)	0.162	0.997	0.000	0.287	0.060	0.465
SF-36: Bodily Pain (BP_NBS)	0.355	0.720	0.014	0.821	0.170	0.847
SF-36: General Health (GH_NBS)	0.002	0.898	0.000	0.174	0.110	0.077
SF-36: Vitality (VT_NBS)	0.007	0.196	0.052	0.037	0.257	0.076
SF-36: Social Functioning (SF_NBS)	0.370	0.165	0.003	0.133	0.251	0.901
SF-36: Role-Emotional (RE_NBS)	0.108	0.088	0.128	0.052	0.246	0.224
SF-36: Mental Health (MH_NBS)	0.357	0.559	0.992	0.244	0.544	0.351

[1] Difference between end of first year and baseline sig diff from zero for entire sample
[2] Sig difference in change in this variable over first year depending upon gender (independent t-test using wide format change value calculated grouping by treatment group)
[3] p-value of the main effect when the variable is added to the MIXED model as a main effect

[4] p-value of the interaction term when added as randcode*variable interaction (and main effect)
[5] p-value of the interaction term when added as timept*variable interaction (and main effect)
[6] p-value of the three-way interaction when added as a randcode*timept*variable interaction (with both 2-way interactions and main effects)

APPENDIX 3.2_Syntax for graphs

Syntax for graph 'weight over first year by treatment group and perceived control over weight'

```
MIXED weight BY ID randcode WITH timept control
  /CRITERIA=CIN(95) MXITER(10) MXSTEP(1) SCORING(1)
SINGULAR(0.000000000001) HCONVERGE(0, ABSOLUTE)
    LCONVERGE(0, ABSOLUTE) PCONVERGE(0.000001, ABSOLUTE)
  /FIXED=randcode timept control control*timept control*randcode
control*timept*randcode
 randcode*timept | SSTYPE(3)
  /METHOD=REML
/emmeans tables(randcode) compare(Randcode) with (control = 2.8 timept=1)
/emmeans tables(randcode) compare(Randcode) with (control = 7.2 timept=1)
/emmeans tables(randcode) compare(Randcode) with (control = 2.8 timept=2)
/emmeans tables(randcode) compare(Randcode) with (control = 7.2 timept=2)
/emmeans tables(randcode) compare(Randcode) with (control = 2.8 timept=3)
/emmeans tables(randcode) compare(Randcode) with (control = 7.2 timept=3)
  /RANDOM INTERCEPT timept|subject(ID) COVTYPE(UN).
```

Syntax for graph with weight locus of control

```
MIXED weight BY ID randcode WITH timept WLOC
  /CRITERIA=CIN(95) MXITER(10) MXSTEP(1) SCORING(1)
SINGULAR(0.000000000001) HCONVERGE(0, ABSOLUTE)
    LCONVERGE(0, ABSOLUTE) PCONVERGE(0.000001, ABSOLUTE)
  /FIXED=randcode timept WLOC WLOC*timept WLOC*randcode
WLOC*timept*randcode
 randcode*timept | SSTYPE(3)
  /METHOD=REML
/emmeans tables(randcode) compare(Randcode) with (WLOC = 6 timept=1)
/emmeans tables(randcode) compare(Randcode) with (WLOC = 11.7 timept=1)
/emmeans tables(randcode) compare(Randcode) with (WLOC = 6 timept=2)
/emmeans tables(randcode) compare(Randcode) with (WLOC = 11.7 timept=2)
/emmeans tables(randcode) compare(Randcode) with (WLOC = 6 timept=3)
/emmeans tables(randcode) compare(Randcode) with (WLOC = 11.7 timept=3)
  /RANDOM INTERCEPT timept|subject(ID) COVTYPE(UN).
```

CHAPTER 4

DAILY WEB-BASED WEIGHT MONITORING FOR THE PREVENTION OF WEIGHT GAIN IN WOMEN

Introduction

Despite concern about age-related weight gain, few randomized controlled trials have been conducted using potential interventions to halt the gain in the normal-weight healthy adult population prior to 2008 (Lombard, Deeks, & Teede, 2009). Lombard et al.'s (2009) systematic review includes a brief section on self-monitoring, pointing out that interventions involving self-weighing showed a relationship between behavior and weight whereas other types of self-monitoring such as recording of diet or physical activity did not show a clear relationship with weight. Since 2008, this review was followed by another review concerned with weight gain over the period of life termed emerging adulthood (Laska, Pelletier, Larson, & Story, 2012) and studies regarding already overweight adults (e.g. (van Genugten, van Empelen, Flink, & Oenema, 2010)). Lombard and colleagues (Lombard, Deeks, Jolley, Ball, & Teede, 2010) tested a low intensity intervention for women with young children who had Body Mass Indexes (BMIs) in the middle of the overweight range. This intervention was derived from social cognitive theory and included a self-weighing component. The control group was given standard public health messages. After one year, there was no weight change in the intervention group and the control group had gained an average of 0.83 kgs.

It has been postulated that both age-related weight gain and secular increase in body weights can be due to a small, persistent increase in caloric intake over time

(Hall et al., 2011; Levitsky & Pacanowski, 2011), fueled by the influx of novel food and beverages. In addition, others have reported that environmental factors such as portion size (e.g. (Rolls, Morris, & Roe, 2002; Wansink & Kim, 2005)), and behavioral changes such as the number of times a person eats per day, have assisted in increasing energy intakes (Duffey & Popkin, 2011). These environmental stimuli may act as “primes” both at the level of the conscious and nonconscious to promote consumption. Primes can be physical objects, like restaurant signs, or sensory stimuli, like the smell of pizza, and are believed to nonconsciously activate mental schema and can influence thoughts, perceptions, and behavior (Bargh, Chen, & Burrows, 1996). It has been estimated that a surplus of between 20 and 300 calories a day can explain this change in body weight (Hall et al., 2011; Hill, 2009; Levitsky & Pacanowski, 2011; Swinburn et al., 2009). This increase in daily intake may be imperceptible.

To model the effect of gradual, persistent weight gain, Levitsky and colleagues (Levitsky, Garay, Nausbaum, Neighbors, & Dellavalle, 2006) studied college freshmen: a group believed to gain weight more rapidly than the population at large. In a replicated experimental trial, those researchers found that having college students email their weight daily to the research team and view a graph of their weight sent by the research team was sufficient to prevent weight gain normally seen over the first three months of college. It was hypothesized that the scale and self-monitoring technique may act as a ‘negative prime’, countering the stimulating effect of food primes thereby allowing students to prevent gaining weight.

Although the study (Levitsky et al., 2006) showed the effectiveness of the “Caloric Titration Method” (CTM) over a three-month period, it is not clear whether it would be equally as effective for preventing age-related weight gain over longer periods in an older population. The present study addresses this concern by providing a sample of women using the CTM for a two year period with the hypothesis that the CTM method would prevent age-related weight gain.

Methods

Procedure

As part of a larger study (see CHAPTER 2), 178 individuals responded to newspaper advertisements, email newsletters, and a Public Service Announcement on a local radio station. Advertisements stated that anyone interested in participating in the study who was over the age of 18, was not pregnant or planning to become pregnant, was not diabetic, did not have an eating disorder or history of an eating disorder, and had a Body Mass Index of greater than 27.0 kg/m2 should contact the study investigator via email.

Of the 178, sixteen were interested in participating but did not meet the BMI cutoff. These individuals were invited to participate in another study, a 'weight maintenance' cohort which is the focus of this chapter.

All participants were invited to an initial meeting with Dr. David Levitsky in the fall of 2010 where he discussed evidence-based strategies for preventing age-related weight gain. Sessions were recorded for those who did not/could not attend. Multiple initial rescheduled sessions were planned to optimize participation. Only one interested weight maintenance participant did not attend an initial session, leaving a sample size of fifteen. All fifteen participants were provided with a standard, commercial bathroom scale (American Weight Scales Model 330 LPW) and access to a computer website (http://weightloss.human.cornell.edu/) where they were asked to register and enter their weight daily. The website produced graphs of the participant's weight on the y-axis and time (date) on the x-axis. After the first 8 days of entries, a green line was placed on the graph, indicating the starting weight that the participants should try to maintain.

Weight measurements were taken by the researchers at baseline, 6 months, 12 months, and 24 months after the initial session. Online questionnaires were disseminated at each of these time points. Also, 18 months after the initial session (time point 4) a questionnaire was administered. The questionnaire assessed psychological factors and their relationship to weight maintenance and the CTM.

Demographic information and questions about dieting history were assessed at baseline as part of the baseline online questionnaire. The Three Factor Eating Questionnaire (TFEQ) (Stunkard & Messick, 1985) was used to assess cognitive restraint, hunger and disinhibition, along with later proposed subdivisions of cognitive restraint, flexible control and rigid control (Westenhoefer, 1991). The TFEQ assesses assessed intentions of the individual as compared to behavioral caloric restriction and weight change. The TFEQ measures the respondent's perception of their eating behavior. The TFEQ has been used widely in the literature, Lowe and Thomas (2009) review its history and applications in different samples. The TFEQ was administered at baseline and the 24-month end point of the study to calculate change scores.

Repeated measurements were taken on other psychological variables via online survey at baseline, 6 months, 12 months, 18 months and 24 months. These included a scale composed of 10 items assessing general self-efficacy (Schwarzer & Jerusalem, 1995), perceived control over weight (assessed in three ways: a 1-item question directly asking how in control participants felt over their weight, Weight Locus of Control (WLOC) (Saltzer, 1982), and Self Mastery (Pearlin, Lieberman, Menaghan, & Mullan, 1981), and quality of life assessed by the SF-36 (Ware & Sherbourne, 1992).

Self-efficacy measures the extent to which individuals believe they can accomplish something. To directly assess perceived control over body weight, a question was asked at each of five time points very directly assessing perceived control. This question was “Overall, how much do you feel in control of your weight?” with answers ranging from 1 (not in control) to 10 (in full control). The Weight Locus of Control (WLOC) scale consists of 4 items with forced-choice response categories (Saltzer, 1982). This scale was designed as an adaptation of Rotter’s Internal-External Locus of Control (LOC) Scale (Rotter, 1966), which is predictive of a personality trait that is relatively stable over time. The 10 item original LOC scale does not focus specifically on weight, but on perceptions regarding why events happen. Someone with an internalized locus of control believes they are the primary determinant of events in their life, whereas someone with an externalized locus of control believes forces outside of themselves, like others or chance, determine outcomes in their life. A 7-item questionnaire, where the response to each item is based upon a four point scale, was developed as part of an effort to understand life stressors (Pearlin & Schooler, 1978). The concept of self-mastery is defined as the “extent to which one regards one's life-chances as being under one's own control in contrast to being fatalistically ruled” (Pearlin & Schooler, 1978:5). This scale is also directed toward a locus of control. The self-mastery scale has been used more widely in the literature than the WLOC scale, so it can be used comparatively with other studies in a more general sense, whereas the WLOC scale is directed to measure perceived control in one area. It is also of interest to learn to what extent a predicted increase in sense of control over body weight translates to perceived control in more general areas of life, which is another reason to include the self mastery scale. The Macarthur foundation (Seeman, 2008) describes Pearlin & Schoolers' Self Mastery scale (1978) as possibly the most widely used in measuring the mastery construct. The Medical Outcomes Study Short-Form Health Survey (SF-36) was developed phenomenologically, with the assertion that the perceptions of the patient are the patient's reality (Ware & Sherbourne, 1992). The SF-36 measures two facets of quality of life: physical health (measured by the four concepts: physical functioning, role limitations due to physical problems, bodily pain, and general health perceptions) and mental health (measured by four concepts: vitality, social functioning, role limitations due to emotional problems, and mental health). Thirty-six items are proposed in likert-scale format. Though between-person differences can be expected for subscales at a specified point in time, the within-person change in rating over time is the dependent variable of interest. The SF-36 was selected due to its thoughtful development, rigorous testing (Mchorney, Ware, & Raczek, 1993; Mchorney, Ware, Lu, & Sherbourne, 1994) and exposure in the literature (almost 4,000 citations to date).

Hunger was also assessed at each of the 5 aforementioned time points using Visual Analog Scales online. At each time point, hunger was assessed 8 times throughout the day by asking computerized questions such as: "For each item, please move the slider to indicate how you feel in general. ‘How hungry do you usually feel before breakfast?’, ‘How hungry do you usually feel between lunch and dinner?’”. Methods were approved by the University Institutional Review Board.

Participants

All fifteen participants were women. Their average age was 46 years (range 28 to 62; SD of 9 years). Fourteen self-identified as white and one self-identified as African American. On average, the sample had completed a college degree (range one year of college through doctoral degree). Average BMI was 25.1 ± 1.3 kg/m^2.

Results

Withdraws and loss to follow ups

One participant withdrew after approximately 9 months using the program and had entered 231 weights in this timeframe. This decision was made through discussions between the study Registered Dietitian and participant, as it did not seem that it was in the participant’s best interest to continue frequent weighing; it was suggested that this participant withdraw. Of note, this participant reported daily self-weighing prior to starting this study. Measurements were still able to be collected at time points with the participant blinded to the scale, but were not included in analyses past the 6 month mark, since the participant was no longer using the treatment and was instead followed as a case study.

Final 24-month weight measurements were not able to be collected from two participants due to relocation or loss to follow up.

The primary analysis to examine whether using the CTM was effective in preventing weight gain in this group of women was a mixed model, allowing for a random intercept and random slope for each individual's weight trajectory. The result (without using covariates) suggested that the effect of time was not significant (p = 0.897), meaning that the slope of the mean regression line of the participant's individual weight trajectories was not significantly different from zero. The syntax and parameter estimates for this model can be found in Appendix 4.1.

When controlling for Age alone, Education alone, or Age and Education, the significance of the effect of time remained unchanged (ps = 0.886, 0.881, 0.872, respectively).

Psychological variables' interaction with time on the effect of weight

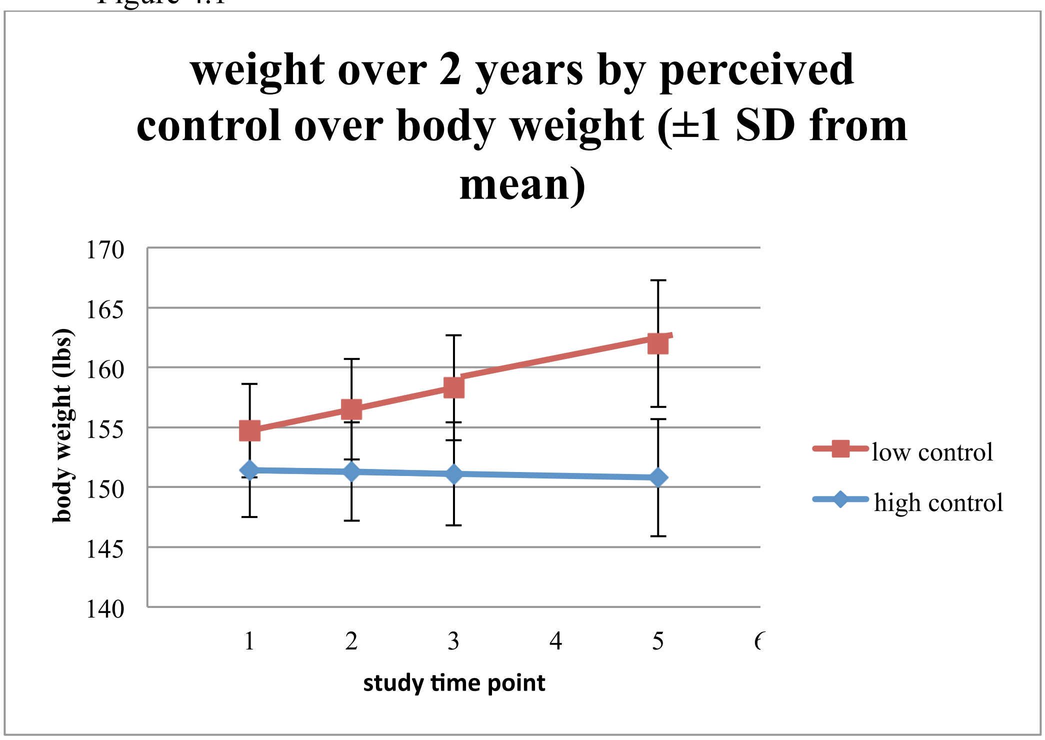
All psychological variables were tested as main effects in the aforementioned mixed model (dependent variable was body weight). The syntax for the mixed model and parameter estimates as well as p-values for psychological variables as main effects are listed in Appendix 4.1.The p-values of psychological variables' interaction with time can also be found in Appendix 4.1. The term of interest is the interaction between each psychological variable and time. This means that participants scoring high or low on the psychological variable showed a different relationship with change in weight over time. Due to the number of comparisons being made, only terms with a p-value less than 0.01 were examined further. This left the following interaction terms: control*time, hunger*time, and disinhibition*time.

Control was assessed by asking participants "On a scale of 1 to 10, how much do you feel in control of your weight (1 being not in control at all, 10 being in full control)?" Hunger and disinhibition were assessed using the TFEQ. Because Control, Hunger, and Disinhibition are continuous variables, comparing weight over time for a value one standard deviation above and one standard deviation below the mean allows for understanding how relationships between weight and time differ at different levels of the psychological variable. These values are displayed in Table 4.1.

Table 4.1 Means, standard deviations (SD), and values +/- 1 SD for select psychological variables

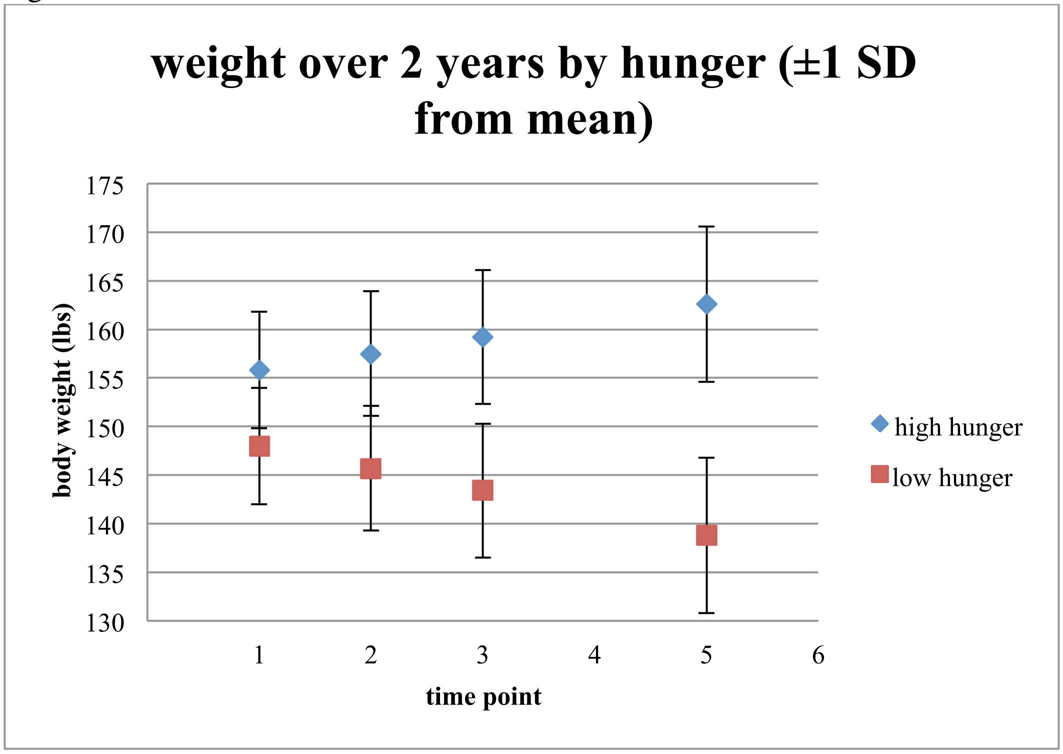
Variable	Mean at baseline	SD	1 SD above mean	1 SD below mean
Control	6.2	1.7	7.9	4.5
Hunger	6.4	3.5	9.9	2.9
Disinhibition	7.7	3.7	11.4	4

Figure 4.1



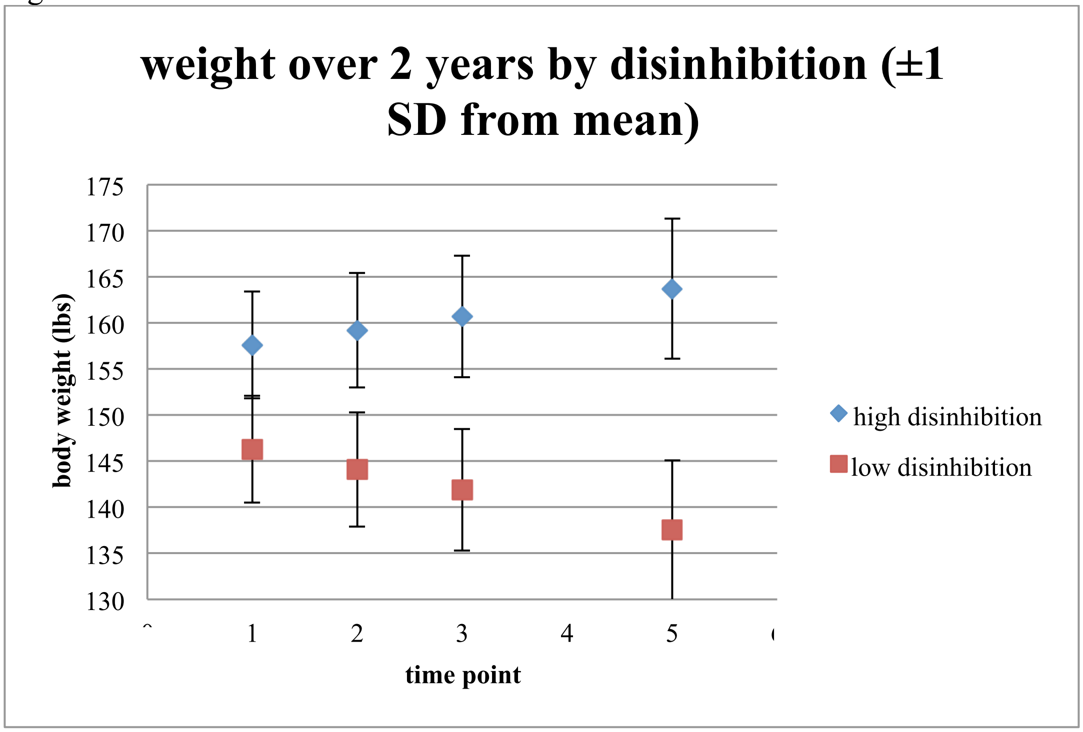
Body weight (lbs) over 2 years of participants +/1 standard deviation (SD) from mean perceived control over body weight

Figure 4.2



Body weight (lbs) over 2 years of participants +/1 standard deviation (SD) from mean hunger

Figure 4.3



Body weight (lbs) over 2 years of participants +/1 standard deviation (SD) from mean disinhibition

As shown in figures 4.1, 4.2, and 4.3, being one standard deviation above or below the mean of "perceived control over body weight", hunger and disinhibition show different relationships with weight over time. Those with low perceived control gained weight while those with high perceived control over their weight slowly lost weight. Those with a lower hunger score slowly lost weight while those with a higher hunger score gained. Similarly, those with a lower disinhibition score lost weight while those with a higher disinhibition score gained.

Psychological variables as dependent variables

Because many of the psychological variables were measured repeatedly, random intercept and slope models were fit for general self-efficacy, perceived control over weight, and several subscales of quality of life: physical functioning, bodily pain, social functioning, role emotional, mental health, and the mental component score as dependent variables. When the model was unable to converge using a random intercept random slope model, a random intercept model was used. Random intercept models were used for the following psychological variables as dependent variables: weight locus of control, self mastery, and the quality of life subscales role physical, general health, vitality, physical component score. Table 4.2 displays the significance level of time in each of the models. This analysis includes all participants that had at least 2 scores out of the five possible scores for each variable.

Table 4.2 Parameter estimates for regressions of psychological variables over 2 years

Variable	**Estimated Intercept (mean ± SE)**	**Estimated Slope (mean ± SE)**	**p-value of time**
General Self-Efficacy	31.0 ± 1.0	0.5 ± 0.2	0.054
Average Hunger	41.6 ± 4.9	-1.9 ± 0.9	0.034
Perceived control over weight	6.2 ± 0.5	0.3 ± 0.1	0.047
Weight Locus of Control	9.0 ± 0.6	-0.3 ± 0.1	0.027
Self Mastery			0.992
Physical Functioning			0.295
Role Physical			0.871
Bodily Pain			0.667
General Health			0.606
Vitality			0.321
Social Functioning			0.594
Role Emotional			0.472
Mental Health			0.679
Physical Component Score			0.353
Mental Component Score			0.859

As Table 4.2 shows, only 4 variables had an estimated linear trajectory that was significantly different from zero: general self-efficacy (borderline), average hunger, perceived control over weight, and weight locus of control. It appears that over the two years of the study, general self efficacy and perceived control over weight tended to increase, while both average hunger and weight locus of control decreased. A decrease in weight locus of control indicates moving toward a more internal sense of control over weight, which is in line with an increase in perceived control over weight.

Slope of psychological variables as correlate of 2 year weight slope

Essentially, the multilevel form of the data allowed for each participant to have their own fitted regression line to their maximum of 4 weight measurements. Similarly to the weights, many of the psychological measurements were taken at 5 time points (general self-efficacy, quality of life, and hunger at 8 points throughout the day), each of these variables were fitted to an individual regression with time as the independent variable. For hunger, a composite score was created by averaging the 8 assessments at each time point. The average hunger score at each of the 5 time points was used to create a linear regression for each participant.

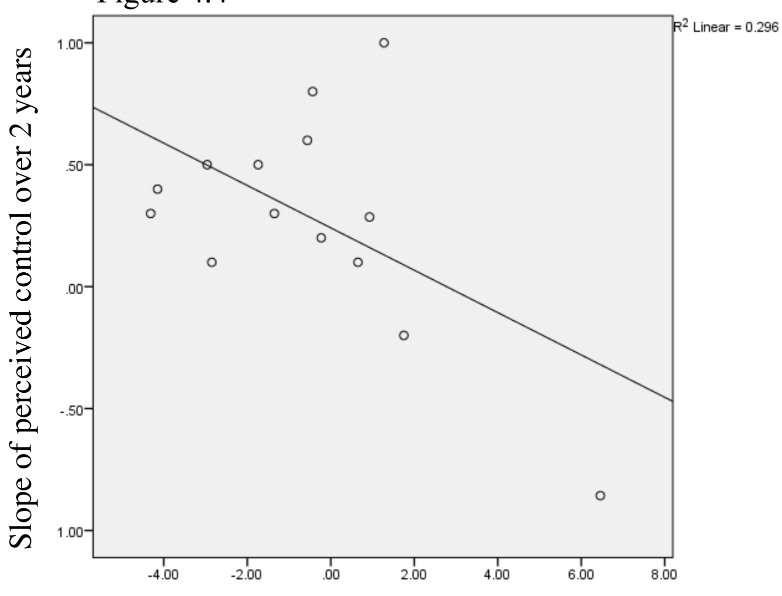
Assessing the correlation between the change over time (slope of time) in weight and the change over time (slope of time) of psychological variables allowed the exploration of whether there was an association between change in one of these with change in the other. To test for statistical significance, a linear regression model was used for each combination to see if the slope of the regression line was significantly different from zero.

The following psychological variables did not show a relationship between the slope of their change over time and the slope of the change in weight over time:

average hunger (p = 0.511), Self Mastery (p = 0.087), weight locus of control (p = 0.584), General Self-Efficacy (p = 0.204), Physical Functioning (p = 0.822), Role Physical (0.542), Bodily Pain (p = 0.381), General Health (p = 0.940), Vitality (0.407), Role Emotional (p = 0.779), and Mental Health (0.532). The slopes of the Physical Component Summary and Mental Component Summary were not tested since there did not appear to be a relationship between their sub factors and slope of weight change.

The following psychological variables showed a significant correlation between the slope of their change over time and the slope of the change in weight over time: perceived control over body weight (p = 0.044) and slope of Social Functioning (p = 0.011). Figures 4.4 and 4.5 graphically display these results.

Figure 4.4

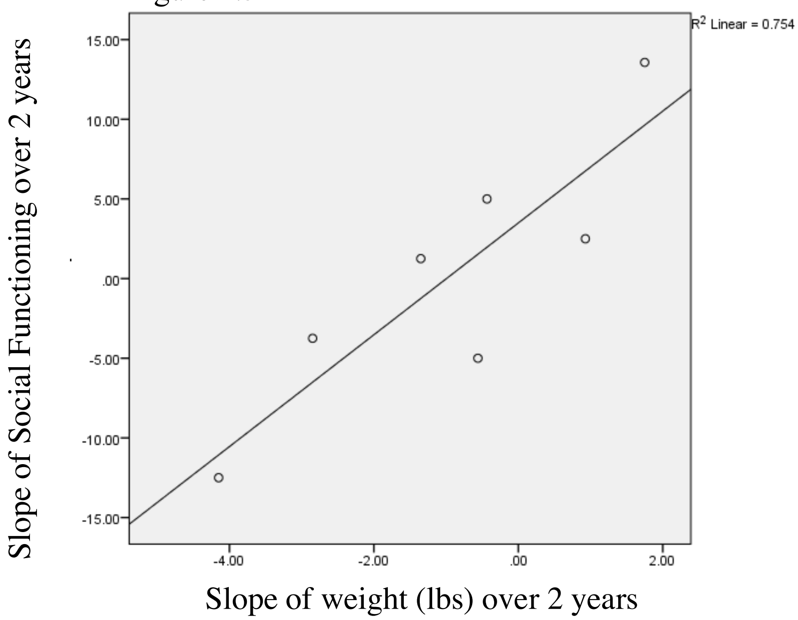


Graph displaying slope of perceived control over body weight over 2 years versus slope of weight over 2 years

It appeared that one data point determined this relationship: The participant that gained a lot of weight and experienced a feeling of loss of perceived control over their weight. When this data point was removed, the slope of the regression line was no longer significantly different from zero (p = 0.928).

For slope of Social Functioning:

Figure 4.5



Graph displaying slope of Social Functioning over 2 years versus slope of weight over 2 years

Though there appeared to be a relationship between the slope of weight over 2 years and the slope of Social Functioning, repeatedly measured over 2 years, due to the number of tests that were done, even a p-value of 0.011 would not be significant if sufficiently correcting for the number of comparisons.

Discussion

This study revealed that the use of a simple behavioral technique – daily self weighing and viewing of daily body weight – was effective for preventing age-related weight gain over a two year period in a sample of females. This method had previously been established in preventing weight gain in a younger population known to gain at an accelerated rate (Levitsky et al., 2006).

Age-related weight gain

Preventing age-related weight gain rests on the assumption that the population is gaining weight as they age. It is estimated that the average US adult gains about a pound per year. When investigating the origins of this value, one of the early places this value appears is in a publication by Jeffery and French: "Between the ages of 20 and 50 years, average weight gain per year among adults in the United States is approximately 0.5 to 1kg. Slowing this rate of weight gain would be an important step in reducing the impact of obesity. However, methods for accomplishing this objective have, to date, received little research attention (Williamson, Kahn, & Byers, 1991)[7]" (Jeffery & French, 1999, p. 747).

The referenced article was published by Williamson and colleagues in 1991 and used data from the National Health and Nutrition Examination Survey (NHANES) follow up study to estimate the 10-year incidence of obesity in black and white women. Williamson and colleagues present mean 10 year weight change for black and white women aged 30-55. Crude means for yearly weight gain are 2.0 (±1.1) kg for blacks and 1.9 (±0.4) kg for whites. Yearly weight gain would then be 0.2 kg for blacks and 0.19 kg for whites. It is possible that this statistic is misleading due to the age group presented. Kuczmarski (1992) uses Williamson's NHANES follow up data and in Table 13 (p 501S) presents a 10 year change in weight for men and women aged 25-34 to be 2.9 kg and 3.5 kg respectively. For 35-44, this value is 1.6 kg and 2.5

kg per year respectively (Kuczmarski, 1992). Assuming that Jeffery and French are citing the statistic of average weight gain, it is not clear if weight trajectories for women can be used to describe the "average US adult" as many studies find that gender moderates the weight change relationship (Chiriboga et al., 2008; Kuczmarski, 1992; Williamson, 1993) as women might be more variable in their weight change than men.

Other estimates for weight gain with time have been made based on longitudinal studies. Colditz et al (Colditz, Willett, Stampfer, London, Segal, & Speizer, 1990) used data from the Nurses' Health study and found an average of a 1.9 kg gain in the first 4 year follow up period, and an average of 1.6 kg gain in the second four year follow up period (Colditz, et al., 1990). Of note is that the values in this study were self-reported. Although self-reported weights correlate very highly with measured weight (Colditz, et al., 1990; Gorber, Tremblay, Moher, & Gorber, 2007; Sobal, Hanson, & Frongillo, 2009), both in this study ($r = 0.96$) and others, reporting correlations near 0.97, it is possible for reported weights to systematically differ from actual weights. In the case of this study, reported weight was about 1.5 kg less than actual weight. For studies that are estimating obesity and overweight prevalence and or incidence, this poses an accuracy problem.

Psychological factors and prevention of weight gain

Psychological factors are often discussed with reference to weight loss, but less discussed in reference to preventing weight gain. Levine (2007) measured restraint, hunger, and disinhibition and found that scoring lower on hunger was associated with prevention of weight gain. This is consistent with what was found and discussed in this analysis. Levine and colleagues also found relationships between increases in dietary restraint and decreases in disinhibition and weight maintenance. However, this analysis was done by dichotomizing participants into weight gainers and weight maintainers. In our analysis, weight is always considered a continuous variable, as we have found in past analyses that dichotomizing may produce results that do not replicate when analyzing the variable continuously (CHAPTER 5, Allison, Gorman, & Primavera, 1993; MacCallum, Zhang, Preacher, & Rucker, 2002). Our sample was not large enough to detect statistical significance, there was an inverse relationship between change in disinhibition and weight change controlling for initial BMI ($r = -0.583$, $p = 0.06$).

Limitations & Conclusion

A major limitation of this study is lack of a comparison group. Since there are few studies that follow participants for 2 years; however, we thought it was important to include these results despite the shortcoming of a lack of comparison group. Though imperfect, we are constructing an estimate for weight change in a comparison group based on previously published literature from our own sample (same sample as was recruited for CHAPTER 2) as well as estimates from published literature. Note: studies that focused on females with a mean age less than the youngest participant in this sample (28 years old; for example (Eiben & Lissner, 2006) report a mean age of controls of 22.3 years) were not included due to the proposition that age-related weight gain may be accelerated in young adults (Hebden, Chey, & Allman-Farinelli, 2012; Nelson, Story, Larson, Neumark-Sztainer, & Lytle, 2008). In addition, studies that did not have information available for females alone (e.g.(Jeffery & French, 1999)) were not included due to potential differences between females and males.

Table 4.3 Comparison of average weight change over one and two years with control groups from published studies

This Study					
Author	**Year**	**Sample**	**Treatment**	**Weight change over one year**	**Weight change over two years**
Pacanowski & Levitsky (present sample)	2010-2012	Women interested in losing weight, did not meet BMI cutoff, offered opportunity for preventing weight gain n = 15 BMI = 25.1 ± 1.3 Age = 46 ± 9	40 minute information session about preventing weight gain	- 1.4 ± 3.8 kgs (n = 14)	-0.9 ± 4.9 kgs (n = 12)
Comparison Control Groups					
Author	**Year**	**Sample**	**Control treatment**	**Weight change over one year**	**Weight change over two years**
Lombard et al.	2010	Women with young children, n = 123 BMI = 28.09 ± 5.79 Age = 40.26 ± 4.80	Public health messages	0.83 kgs (95% confidence interval 0.12 to 1.54)	-
Pacanowski & Levitsky	2010-2011	Women from the control group of the CTM n = 56 BMI = 33.3 ± 5.4 Age = 48.2 ± 9.9	One information session at the beginning of the year	Mean = -1.4 lbs; SD = 10.1 lbs = - 0.64 kg; SD =4.6 kgs	N/A (entered weight loss intervention)

Levine et al.	2007	Women in the control group n = 93 BMI = 25.0 ± 2.3 Age = 35.4 ± 5.3	Information only	-	0.3 kgs (SD = 1.4 kgs)

Over the first year, the weight maintainers' weight change was not significantly different from zero (mixed model results: p-value for time = 0.469; 95% CI for weight change estimate = -3.6 lbs, 1.8 lbs; - 1.6 kgs, 0.8 kgs). When estimating the average weight change using a t-test comparing the average within participants difference between weight at end of one year and weight at baseline, the results are that the average weight change was -3.1 ± 8.4 lbs (- 1.4 ± 3.8 kgs) and this value was not significantly different from zero (two tailed t-test p = 0.194; n = 14; participant that withdrew at 9 months did not have a value for this time point). The 95% CI for this estimate is -8.0 lbs; 1.8 lbs (- 3.6 kgs; 0.82 kgs). This overlaps with the 95% CI estimate of control group weight change in the first year in Lombard and colleague's study (2010). Thus, it can be assumed that the weight change over one year was not significantly different between the group of maintainers discussed here and a control group in a comparable study (Lombard et al., 2010).

When comparing the year 1 weight change of the weight maintainers to the year 1 weight change of the control group in the CTM weight loss study, there is no significant difference (95% CI (-8.0 lbs; 1.8 lbs) overlaps estimate (-1.4 lbs)). The comparison to the control group in CHAPTER 2 is appropriate because these women answered the same ads at the same University to participate in a weight loss trial.

However, the women in the CTM control group had a BMI on average 8 kg/m2 units higher than these women, which could influence results. Regardless of whether or not this is an appropriate comparison, the weight change over one year in this sample of maintainers was not significantly different from the weight change over one year of a control sample of a weight loss study recruited from the same population.

Weight change over 2 years in this weight maintenance cohort was -2 ± 10.7 lbs (-0.9 ± 4.9 kgs; n = 12). The 95% CI for this value is -8.8 lbs; 4.8 lbs (-4.0 kgs; 2.2 kgs), which overlaps with the estimate obtained from Levine et al's study (2007), indicating that the values are not significantly different from one another. Thus, over two years, the weight change in the weight maintainers group was not significantly different from a control group of women in a comparable study (Levine et al., 2007).

This study has a number of limitations, the most deleterious being lack of a comparable control group as already discussed. Several other minor limitations are present. First, it is possible that knowing they were about to be weighed influenced participant's behaviors prior to the weight measurement. An additional weight measurement was taken voluntarily at 9 months without informing participants beforehand (participants were meeting with the researchers for an interview). The value of the 9 month weigh in was not significantly different from the value of the 6 month or 12 month weigh ins ($p > 0.05$). It is also possible that our sample size of 15 was not large enough to detect this difference. Second, because the sample size is small, it is not possible to determine whether lack of a statistically significant finding is due to insufficient power or there being no effect – especially with regard to weight change. We did not find a significant difference in comparing the weight change between the group in our study and control groups in other studies; this could be because there is no real difference or because the effect size is so small that a larger sample size is needed to detect it at a significant level. Third, generalizations are limited to the homogeneity of race, gender, and age of the sample.

Due to the study design, none of these psychological variables were manipulated. So, it could be that when people lose or gain weight, they then answer questions about their eating behaviors or weight control beliefs in a way that justifies their weight change. Alternatively, the psychological factors could predict weight change. This study does not allow for assessment of directionality of the relationship between psychological variables and weight change.

None of the slopes of the change in psychological variables correlated with the slope of the change in weight for participants in this study. There could be several reasons for this. First, maybe there is no relationship between these two things. Second, our sample size may not be adequate to detect this relationship. Finally, there may be a relationship between change in weight and change in psychological factors, but since this group did not significantly change in weight over the 2 years of the study, there may have not been enough of a weight change in an individual level to see this relationship if it does exist.

It is possible that self-weighing may adversely affect certain populations as researchers have suggested (Dionne & Yeudall, 2005; Ogden & Whyman, 1997; Strimas & Dionne, 2010). Using this study as an indicator, this seemed to apply to about 1 out of 15 participants of this age and gender. Though future research is necessary to understand the effects of self-weighing and visual feedback on other groups, it must be kept in mind that some individuals may respond adversely to this treatment. Future research identifying these individuals more accurately for screening purposes would be useful.

Despite these limitations, this research adds valuable knowledge to the published literature. In addition to displaying a method that has successfully prevented weight gain in a population known to gain weight rapidly, this technique has now been shown to assist in weight gain prevention in adult females. Future studies exploring this method for excess weight gain prevention in populations at risk (e.g. pregnancy, age-related weight gain, people that have lost weight) are warranted. Hopefully future studies will be able to contribute to identifying more precisely individuals that would be helped by frequent weighing as a long term weight control strategy.

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APPENDIX 4.1 Mixed model syntax, parameter estimates, and psychological variables

```
MIXED weight BY ID  WITH timept
  /CRITERIA=CIN(95) MXITER(10) MXSTEP(1) SCORING(1)
SINGULAR(0.000000000001) HCONVERGE(0, ABSOLUTE)
    LCONVERGE(0, ABSOLUTE) PCONVERGE(0.000001, ABSOLUTE)
  /FIXED= timept | SSTYPE(3)
  /METHOD=REML
 /RANDOM INTERCEPT timept|subject(ID) COVTYPE(UN)
/PRINT solution
 /SAVE=RESID PRED.
```

Fixed Effects

Type III Tests of Fixed Effects[a]

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	13.917	1819.009	.000
timept	1	13.727	.017	.897

a. Dependent Variable: Weight (lbs).

Estimates of Fixed Effects[a]

Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Intercept	152.965388	3.586540	13.917	42.650	.000	145.268704	160.662072
timept	-.101513	.768597	13.727	-.132	.897	-1.753066	1.550040

a. Dependent Variable: Weight (lbs).

Variable	Main effect [1]	Time [2]	Variable*time interaction [3]
Age_1	0.774	0.886	0.138
Education	0.720	0.881	0.720
Important_losewt2 (categorical)	0.065	0.887	0.167
Times_losewtpastyr	0.005	0.916	0.660
Times_losewtlifetime	0.144	0.968	0.690
OnDiet	0.424	0.877	0.907
Dietinpast	0.631	0.899	0.383
Monthsondiet	0.313	0.942	0.857
successpastdiet	0.706	0.930	0.730
Height_avg	0.000	0.830	0.016
Control_long	0.001	0.661	0.008
Restraint (baseline)	0.937	0.583	0.361
Restraint_change	0.731	0.757	0.482
Hunger (baseline, TFEQ)	0.326	0.622	0.003
Hunger_change (TFEQ)	0.112	0.710	0.050
Disinhibition	0.853	0.879	0.008
Disinhibition_change	0.278	0.768	0.181
Flexiblecontrol	0.741	0.592	0.363
Flexiblecontrol_change	0.692	0.759	0.708
Rigidcontrol	0.521	0.589	0.428
Rigidcontrol_change	0.599	0.766	0.384
SF-36: Physical Functioning (PF)	0.830	0.618	0.068
SF-36: Role Physical (RP)	0.848	0.584	0.128
SF-36: Bodily Pain (BP)	0.944	0.584	0.145
SF-36: General Health (GH)	0.948	0.583	0.734
SF-36: Vitality (VT)	0.606	0.599	0.348
SF-36: Social Functioning (SF)	0.950	0.585	0.371
SF-36: Role-Emotional (RE)	0.975	0.585	0.233
SF-36: Mental Health (MH)	0.777	0.594	0.974
SF-36: Physical Summary Score (PCS)	0.970	0.587	0.193
SF-36: Mental Summary Score (MCS)	0.981	0.586	0.979

[1] p-value for variable when included as a main effect in the model
[2] p-value for time when this variable is included in the model
[3] p-value for the variable*time interaction when this term along with main effects of each are included in the model

CHAPTER 5

PRIMING BODY WEIGHT BY WEIGHING AND RESPONSES TO EATING BEHAVIOR QUESTIONS

Introduction

Existing data suggest that self-weighing aids weight loss and improves weight maintenance (Burke, Wang, & Sevick, 2011; Gokee-Larose, Gorin, & Wing, 2009; Klem, Wing, McGuire, Seagle, & Hill, 1998; Levitsky, Garay, Nausbaum, Neighbors, & Dellavalle, 2006; Vanwormer, French, Pereira, & Welsh, 2008; VanWormer et al., 2009). The mechanism through which self-weighing influences body weight has not been determined, and there are a number of reasonable possibilities. Weighing may merely provide information that could guide eating behavior or behaviors involved in changing energy expenditure much like a biofeedback system (Smith, 1991). Alternatively, any change in weight may either positively or negatively reinforce weighing behaviors that led to the change.

An interesting potential mechanism to account for the effect of self-weighing on weight control is that weighing on a scale may act as a “prime” that affects subsequent responses to environmental stimuli. Though traditionally primes refer to concepts (Bargh, Chen, & Burrows, 1996), primes can include environmental stimuli that nonconsciously activate mental schema and can influence thoughts, perceptions, and behavior (Bargh et al., 1996). If the act of weighing operates as a prime then it should affect responses to stimuli differently than if weighing did not occur.

The purpose of the present study was to examine the act of weighing as a prime in people completing self-reports of eating behavior. Examples of eating behaviors that were hypothesized to be affected by priming are ‘hunger’, ‘restraint’, and ‘disinhibition’ as assessed by the Three Factor Eating Questionnaire (TFEQ) (Stunkard & Messick, 1985). One’s subjective perception of their level of regulating their own eating is a fundamentally different concept than the objective behavioral weight measurement that could be used as an indication of the degree of regulation. Subjective perception of the degree of restriction used to maintain weight may be different for those of identical body weight.

There is a debate about the psychological helpfulness or harmfulness of weighing in body weight management (Dionne & Yeudall, 2005; O'Neil & Brown, 2005), but it is not currently clear if weighing primes important personal characteristics like hunger, restraint or disinhibition. It is possible that there are individual differences in how being weighed impacts self-perception of eating behavior. For example, Strimas and Dionne (2010) found that self-weighing led to weight gain in restrained eaters and weight loss in unrestrained eaters. Understanding whether the activation of awareness of personal characteristics is affected by weighing in particular populations may help to distinguish between persons that can benefit from weighing versus persons that may be adversely affected.

If being weighed impacts the way people perceive their own eating behavior, this may provide an avenue for understanding why frequent weighing is associated with prevention of weight gain or improved weight control. Furthermore, it is unclear whether the dimensions used in the TFEQ are stable traits or malleable constructs; Lowe & Thomas (Lowe & Thomas, 2009) only cite two studies examining test-retest reliability over periods of longer than a few weeks. If there are significant between-group differences in TFEQ subscale score for each of the eating behaviors of interest – restraint, disinhibition, and hunger – this may indicate that these measures are influenced by environmental circumstances. This would mean that the order of when weight measurement is taken during a study, at a healthcare practitioners' office, or other situations may affect the responses of questionnaires like the TFEQ.

It was hypothesized that TFEQ responses for restraint, disinhibition, and hunger will be higher after being primed by being weighed than the TFEQ responses not primed by weighing. The rationale is that people might not be aware of their weight and be surprised to see their weight, and then use the questions to rationalize or lessen cognitive dissonance between what they expected and the value the scale reported. Most people report their weight to be less than it actually is (Gorber, Tremblay, Moher, & Gorber, 2007), so the number reflected by the scale will likely be more than what people expect to see. This may create a dissonance between what was believed about one's weight and what the scale reflects the actual weight to be. To balance this dissonance, people may answer TFEQ questions about their eating behavior (e.g. "Dieting is hard for me because I just get too hungry"; "I eat anything I want, anytime I want") affirmatively to help to justify why they weigh more than they thought they did. Answering more items affirmatively would lead to an increased eating behavior score.

Methods

Participants

This study sought to assess the effect of priming in a real world setting using individuals who happened to be walking through the public space of each location during the specified time. Participants were over the age of 18 and roughly half male and half female, and of varying ages and ethnicities.

Materials

Stunkard and Messick (1985) developed the Three Factor Eating Questionnaire (TFEQ) to measure three components of eating behavior: ‘cognitive restraint of eating’, ‘disinhibition’, and ‘hunger’. This tool improved upon previous assessments of dietary restraint by acknowledging that the scores were influenced heavily by change in body weight. The TFEQ assesses intentions of the individual as compared to behavioral caloric restriction and weight change. The TFEQ measures the respondent’s perception of their eating behavior. The TFEQ has been used widely in the literature; and Lowe and Thomas (Lowe & Thomas, 2009) review its history and applications in different samples.

Research assistants were provided with a typical bathroom scale (American Weigh 330LPW Low Profile Bathroom Scale; Norcross, GA, USA), printed copies of the TFEQ, a clipboard, pens, and an interview script to use when approaching potential participants.

Procedure

A quasi-experimental between-subjects design was employed. Eight research assistants were trained by the PI to approach adults in a public location in one town on two subsequent Saturdays in the summer of 2011. Research assistants were normal weight and of varying genders and ethnicities. Each researcher was randomly assigned to perform either 'weight first' (weigh participant and then ask them to fill out the TFEQ) or 'survey first' (ask participant to fill out the TFEQ and then weigh them) on the first Saturday of data collection. The second Saturday, the other condition was performed. The study was executed between the hours of 1pm and 5pm to avoid overlapping with mealtimes. Research assistants were directed to collect information from 25 people each Saturday. Issues related to confounding were managed during data collection; for example, on the 'survey first' day, the scale needed to be hidden during the survey administration and potential participants in view of a participant being weighed were not recruited because this could bias results since they might realize they were going to be weighed. In the 'survey first' condition, participants were handled by the researcher keeping the scale concealed in a bag and allowing each participant to complete the survey before being weighed. Procedures were approved by the University Institutional Review Board before the study was conducted.

Sampling was completed in 8 different locations: three different sites in Ithaca, New York; and one site at Case Western Reserve Campus, Cleveland Ohio; Holtsville Ecology Center and Park, Long Island New York; Oakland, California; and Princeton, New Jersey. The three Ithaca locations are frequented by demographically different subpopulations.

On each test day people were approached and asked if they were over the age of 18 and would be willing to take 5 minutes to help a researcher. They were then given either the TFEQ survey, or asked if they could be weighed, or the reverse. The survey questions were limited to the TFEQ to minimize the time burden and maximize the participation rate.

Survey data were collected from 355 individuals. Weight information was collected from 343 individuals (12 individuals refused to have their weight measured). Survey responses were entered and summary TFEQ scores were tabulated according to Stunkard & Messick's (Stunkard & Messick, 1985) original publication of the TFEQ.

Restraint, hunger, disinhibition, and weight all approximated a normal distribution. Data were analyzed for missing values. The items from the questionnaire with the largest percentage of missing values were R50 (6.2% missing); D36 (5.4% missing). All other items had less than 4% missing. Scales were constructed by substituting means of nonmissing items (Acock, 2005).

Sufficient reliability was achieved in this sample for restraint, disinhibition, and hunger (Chronbach's alpha = 0.86, 0.75, 0.79, respectively). Descriptive statistics were performed on all variables along with t-tests to examine the statistical difference between the scale first condition and survey first condition. Pearson's zero order correlations and multiple regressions were also calculated. Analyses were conducted using SPSS v20.

Results

Means and standard deviations for all measures are displayed in Table 5.1.

Table 5.1. Mean score ± standard deviation for three eating behaviors and weight

	Weigh First	N	Survey First	N	p-value for difference*
Dietary Restraint	8.6 ± 5.2	170	8.9 ± 4.9	185	0.28[a]
Disinhibition	6.1 ± 3.4	170	6.0 ± 3.2	185	0.37[a]
Hunger	5.9 ± 3.5	170	5.6 ± 3.4	185	0.22[a]
Weight (lbs)	63.5 ± 37.6	164	62.4 ± 36.2	179	0.78[b]

[a]p values are based on one-tailed t-tests
[b]p values are based on two-tailed t-tests

Overall, no significant differences on any of the three TFEQ eating behavior constructs (cognitive restraint, disinhibition, hunger) were found between the weighing and nonweighing condition. The weighing and non-weighing participants also did not differ in weight.

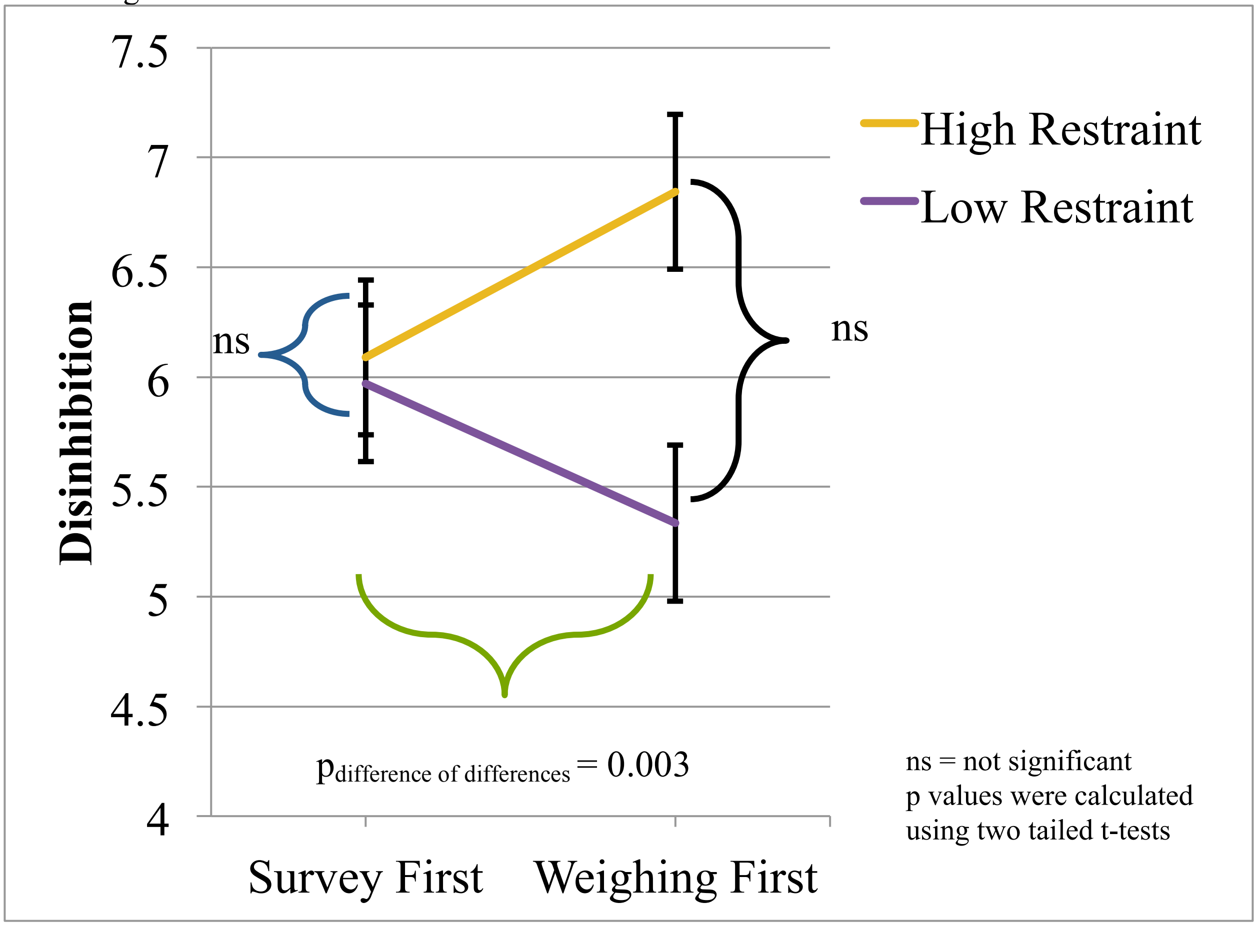
Pearson correlation coefficients were calculated to examine the associations between variables. Weight was weakly but positively correlated with disinhibition using a 2-tailed test ($r = 0.15$; $p = 0.006$) and weakly but negatively correlated with restraint ($r = -0.12$; $p = 0.025$). Heavier participants tended to score higher on disinhibition and lower on restraint.

A linear regression model was calculated to predict body weight based on disinhibition and restraint. The regression equation was WEIGHT = 160.73 +1.82*disinhibition – 1.01*restraint (model significance $p = 0.01$; $r^2 = 0.04$). A one-point increase in disinhibition was related to an almost 2 pound increase in average weight, whereas a one-point increase in restraint is related to an average weight decrease of one pound. Both disinhibition (p = 0.002) and restraint (p = 0.01) were significant predictors of body weight.

A general linear model was fit to examine the effect of condition, restraint, and the condition by restraint interaction on disinhibition score, while controlling for location and weight. When restraint was modeled as a continuous variable, as recommended (Allison, Gorman, & Primavera, 1993; MacCallum, Zhang, Preacher, & Rucker, 2002), this interaction was not significant (p =0.128). However, since other priming studies have found a priming effect when dichotomizing restraint, this analysis was also performed when data were stratified according to median restraint (>8 = high restraint, n = 176; <=8 = low restraint, n = 179). When the same general linear model was run using restraint as a categorical variable, the interaction between restraint classification (high versus low restraint) and weighing condition (survey first versus weight first) was significant (p = 0.048). Hunger was not included as a covariate because of its strong correlation with the dependent variable disinhibition (2-tailed test, r = 0.636, p = 0.000). A sensitivity test was done replacing disinhibition with hunger as the dependent variable, and the dichotomized restraint by condition interaction was not significant (p = 0.141).

The significant interaction between restraint status and condition was further investigated using specific contrasts. Figure 1 displays the interaction and the specific contrasts.

Figure 5.1



Differences in disinhibition score by weighing condition and restraint status

The difference in average disinhibition score in high and low restrained participants was not significant in either the survey condition or the weight condition; however, the difference between these differences was significant at p=0.003 as depicted in the figure.

Discussion

These findings did not support our initial hypotheses that being weighed would increase responses for restraint, disinhibition, and hunger as measured by the Three Factor Eating Questionnaire (TFEQ). Methodologically, it is possible that with a larger sample size, a difference between disinhibition and hunger may have emerged, with the being weighed first condition producing increased scores for these eating behaviors. Substantively, there are a number of possible explanations as to why the findings did not correspond with our hypothesis. Perhaps the most plausible is that although the TFEQ asks questions about eating behavior, the questions examine stable traits rather than malleable behaviors. As psychological traits, the TFEQ scores would be impervious to the more concurrent effects of priming. Overall, it is likely that the ordering of administration of an eating behavior questionnaire and taking weights does not significantly affect responses in most individuals.

In explaining and interpreting these findings, it is important to remember that this study did not measure behavior (e.g. food consumption). When measuring food consumption behavior, Brunner (Brunner, 2010) found that presence of a body weight scale decreased chocolate consumption and Brunner and Siegrist (Brunner & Siegrist, 2012) found that reporting ones weight before tasting chocolates as compared to after tasting chocolates decreased consumption. In addition, activation of self-regulatory concerns, partially done by self-weighing, caused decreased consumption of potato chips (Do Vale, Pieters, & Zeelenberg, 2008). In this study, it could be that the cognitive dissonance experienced by being weighed is not sufficient to change perceptions of long term eating behavior, but as others have found, the anxiety resulting from the dissonance may have an effect on short term consumption regardless of level of restraint (Rotenberg et al., 2005). Alternatively, our primary assumption that people would be surprised to find out their weight may only occur for a subset of the individuals measured. It could be that some of the sample actually expected their weight to be higher than it was and some did not have a preconceived expectation about their weight, attenuating any results from those whose weight was greater than expected.

Some research evaluating effects of food primes has shown that when dichotomizing restraint, restrained individuals, as compared to unrestrained individuals, respond to food primes, such as the smell of food or being instructed to think about food, by consuming more (Fedoroff, Polivy, & Herman, 1997). In this study (Fedoroff et al., 1997), analyses using restraint as a continuous variable were not presented. Wansink and Shimizu found that restrained but not unrestrained eaters were impacted behaviorally by food-related television programs – they consumed more (Shimizu & Wansink, 2011). Those authors stated that restraint was also analyzed as a continuous variable but that results were similar; only dichotomized results were presented. Others have presented results that treat restraint as a dichotomized variable, after noting and providing evidence for a non-linear interaction(Stroebe, Mensink, Aarts, Schut, & Kruglanski, 2008). It is not clear if the interaction would have been observed using regression.

In contrast, some researchers use restraint as a continuous measure (Anschutz, Van Strien, & Engels, 2008; Papies & Hamstra, 2010) and do find significant interactions between restraint and prime manipulation on intake. This provides evidence to support the notion that intake is more variable than responses to the TFEQ or the manipulation of weighing is not strong enough to influence eating behavior scores. It is also of note that the authors using intake as their dependent variable tend to suggest that intake is manipulated nonconsciously. It could be that by asking pointed questions about eating behaviors, we are bringing these behaviors to conscious awareness and reducing the nonconscious priming effect. Interestingly, Stroebe and colleagues (Stroebe et al., 2008) note that in their Study 2 and Study 3, where a manipulation was done prior to participants filling out the Concern for Dieting portion of the Restraint scale, the manipulation did not differentially affect scores. Being that the Concern for Dieting subscale is less than a quarter of the number of items in the TFEQ restraint score, it made sense that an effect might be more apparent using the TFEQ.

The present study found that the difference in disinhibition between highly restrained individuals and low restrained individuals in the survey first condition was significantly different than the difference between highly restrained and low restrained individuals in the weighing first condition. However, this relationship did not maintain significance when modeling restraint as a continuous variable, calling into question the practice of dichotomization, as other researchers have (Allison et al., 1993; MacCallum et al., 2002). Nonetheless, it is important to remember that this study examined the effects of the weight prime in a much more realistic real world setting than laboratory studies, with many more confounding variables. Thus, the indication of a difference in perceived disinhibition by restraint status is supportive of controlled studies finding differences.

Other studies have shown that restrained eaters may react differently than unrestrained eaters when primed with dieting concepts. On a more abstract level, Papies, Stroebe and Aarts (2008) found that by priming dieting, they were able to counter the attentional bias restrained eaters showed toward hedonic foods. Similarly, Anschutz, Van Strien and Engels (Anschutz et al., 2008) found that commercials including slim models or diet products seemed to reinforce the restraint concept in restrained eaters, enabling them to stick to their dieting goal, while neutral ads increased consumption in restrained eaters. The finding that restrained eaters were able to restrain themselves when being primed with dieting was in conflict with many other studies that have shown that dieting stimuli may act as a disinhibitor. Anschutz & colleagues (Anschutz et al., 2008) pointed out the distinction between using the Restraint Scale (Herman, Polivy, & Herman, 1980) and using the Dutch Eating Behavior Questionnaire to measure restraint; the former is confounded with items assessing overeating and may select for restrained individuals that also overeat. This is an important point to note, as the scale used to measure restraint could explain differential research findings.

Some have not found restraint status to interact with food cue exposure (Larsen, Hermans, & Engels, 2012). These authors proposed that their food cue (olfactory) may not have been salient enough to produce results in line with others' findings, as participants were not specifically directed to pay attention to the cue.

The present research has several limitations. As mentioned, to minimize participant response burden, the survey was strictly limited to the TFEQ, so it could be completed in less than 5 minutes. We did not ask about basic demographics including gender, age, and ethnicity. These details could be important in elucidating relationships between weight and perceptions of eating behavior, and not including them could be masking some results. Also, expected weight was not asked before weighing, and reactions to being weighed were not assessed.

Despite these limitations, we found significant relationships between disinhibition, restraint, and weight, that others have also found, which supports the legitimacy of our TFEQ results. Additionally, the borderline significant interaction between restraint and weighing condition is in line with what others have found (Anschutz et al., 2008; Fedoroff et al., 1997; Papies et al., 2008; Shimizu & Wansink, 2011). The relationship between a weight prime and perceptions of long term behavior may be weaker than the relationship between a food prime and actual subsequent consumption. Future research looking at specific subpopulations could help to investigate the relationship between weighing as a prime, body weight and perception of eating behavior.

Veling, Aarts and Papies showed that by having chronic dieters engage in a task that paired an arbitrarily assigned 'no-go' cue (e.g. the letter "p" or the letter "f") with a palatable food, consumption of that food was significantly decreased over a day; this effect was not found in nondieters (Veling, Aarts, & Papies, 2011). In this study, we presented a dieting prime (weighing on a scale) and examined its impact on perceptions of eating behavior. It is possible that dieting cues such as knowing ones' weight could influence consumption, but future research will need to address this issue.

Conclusion

Despite the lack of effect of weighing on measures of eating behavior, future research would be useful to examine the possibility of an effect of weighing on subsequent eating behavior (e.g. consumption) to explain why frequent weighing corresponds with successful weight loss and or maintenance. Future studies should also examine the possibility that this relationship may hold for particular types of individuals (e.g. those that score high on dietary restraint) and should present analyses of restraint as both a continuous and categorical variable and if possible discuss the potential for differential interpretations based on analysis strategy.

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CHAPTER 6

HOW DOES THE CTM (DAILY SELF-WEIGHING AND INDIVIDUALIZED VISUAL FEEDBACK) FACILITATE A SELF-DIRECTED LEARNING PROCESS IN ADULTS?

Introduction

The weight loss intervention used in CHAPTERS 2-4, the Caloric Titration Method (CTM), involves daily self-weighing and visual feedback through the internet. Although published literature has examined self-weighing using different epidemiologic quantitative methodologies (Butryn, Phelan, Hill, & Wing, 2007; Fujimoto et al., 1992; Gokee-Larose, Gorin, & Wing, 2009; Gow, Trace, & Mazzeo, 2010; Heckerman, Brownell, & Westlake, 1978; Jeffery & French, 1997; Jeffery & French, 1999; Klem, Wing, McGuire, Seagle, & Hill, 1997; Levitsky, Garay, Nausbaum, Neighbors, & Dellavalle, 2006; Linde, Jeffery, French, Pronk, & Boyle, 2005; Mahoney, 1974; Mahoney, Moura, & Wade, 1973; Ogden & Whyman, 1997; Oshima, Matsuoka, & Sakane, 2012; Quick, Larson, Eisenberg, Hannan, & Neumark-Sztainer, 2012; Quick, Loth, Maclehose, Linde, & Neumark-Sztainer, 2013; Romanczyk, Tracey, Wilson, & Thorpe, 1973; Romanczyk, 1974; Steinberg et al., 2013; Strimas & Dionne, 2010; Vanwormer, French, Pereira, & Welsh, 2008; Wing, Tate, Gorin, Raynor, & Fava, 2006; Wing et al., 2007), qualitative research on self-weighing is sparse. Few published papers discuss qualitative findings about self weighing. Lynch (2012) included qualitative analyses in the study of gastric bypass patients and found a significant relationship between frequency of self-weighing and objective success in preventing weight regain (Lynch & Bisogni, 2012); however, this particular finding is quantitative in nature and does not describe the 'how' or 'why' patients chose to self-weigh. Although others have published qualitative work regarding self-monitoring in the form of diet monitoring (Burke, Swigart, Turk, Derro, & Ewing, 2009), self-weighing is unique in that the focus on body weight for weight control is contested (Dionne & Yeudall, 2005). The author is unaware of published qualitative work analyzing the process of daily self-weighing in obese and overweight adults from the participant's point of view. Qualitative work is vital to understanding why self-weighing works for some and not others as a weight loss strategy. This chapter investigates how self-weighing operates in a context of a self-directed learning framework for adults in a weight loss program.

A major principle of the CTM is individuals figuring out what works for them to control their weight. This philosophy was developed through observing that in a previous self-weighing study (Levitsky et al., 2006), as many strategies for weight control emerged as participants in the study. This is counter to the philosophy of many weight loss programs that develop a detailed diet and or activity plan for participants to follow. Usually, individuals adhere to a program for a few weeks or months, but eventually resume previous habits contributing to weight regain (Kraschnewski et al., 2010). Reliance on external factors (e.g. a healthcare practitioner/counselor, a structured diet plan or program) may not be sustainable for several reasons. First, the external source of information or support may not be financially feasible for the individual. Health Insurance does not always pay for visits to a dietitian. It may not be realistic for people to pay out of pocket for dietetics counseling, especially when multiple regular visits may be necessary to achieve the desired outcome. Organized weight loss programs are business ventures; they usually charge a fee for participation and purchasing special diet foods is often expensive. Second, time is perceived as a constraint by many. It takes time to learn the structure of a diet program and to purchase specific items to plan meals that fit within the scope of that program. Conceptualizing these external factors as resources to assist in making lifestyle changes may help to internalize perception of control over weight. An individual can piece together parts of different weight loss plans to best meet their needs. For these reasons, the CTM is simple – all that is required of participants is to weigh themselves daily and record their weight on the provided website, where they view the electronically produced graph of their weight over time.

As society becomes increasingly reliant on visual technology, electronic means have emerged to provide feedback that was historically provided by another person. A recent meta-analysis of computer-tailored programs suggests that they do affect health behavior (Krebs, Prochaska, & Rossi, 2010). Using computer-tailored interventions may be a way to increase self-reliance at a reduced cost and time expense, making the interventions available to a larger proportion of the population. If weight regulation is no longer dependent upon external programs or people, but dependent upon the individual, the individual can pick and choose pieces from different strategies that work for them. If the individual is responsible for self-monitoring their own progress, attending regular group meetings or education sessions may not be necessary. This avenue of intervention for weight loss presents an opportunity for adults to engage in a self-directed process of learning what works for them as individuals.

Self-directed Learning

Self-directed learning was articulated by Malcom Knowles in 1975 as “a process in which individuals take the initiative with or without the help of others in diagnosing their learning needs, formulating learning goals, identifying human and material resources, and evaluating learning outcomes.” (Knowles, 1975, p 18). Knowles distinguishes between self-directed learning and other similar terms like ‘independent learning’ or ‘autonomous learning’ by noting that in being self-directed, adults rely on others (“helpers”) to facilitate this process. Knowles’ presentation of his text is relayed in a humanistic manner, beginning by establishing rapport with the reader/learner even though the environment is not face-to-face. He sets a ‘climate’ based upon care for the reader, mutual respect, participatory dialogue, defining teacher/learner roles, and mutual trust by transparently communicating his motives to the reader (Knowles, 1975). Of note, Knowles sees his role “to be that of a guide for, and facilitator of, your inquiry, as well as being a source of information about facts, ideas, and other forms of help.” (Knowles, 1975, p 10). Interestingly, Knowles highlights the importance of teaching skills, not facts, a concept that continues to be emphasized today.

Knowles differentiates between “teacher-directed learning” and “self-directed learning” in terms of assumptions. In Learning Resource A (Knowles, 1975, p. 60), he compiles a table (asking the reader to consider these as poles along a spectrum) differentiating between the assumptions of teacher-directed and self-directed learning:

Table 6.1 Assumptions about teacher-directed versus self-directed learning. From (Knowles, 1975, p. 60)
"

Assumptions		
About	Teacher-directed learning	Self-directed learning
Concept of the learner	Dependent personality	Increasingly self-directed organism
Role of learner's experience	To be built on more than used	A rich resource for learning
Readiness to learn	Varies with levels of maturation	Develops from life-tasks and problems
Orientation to learning	Subject-centered	Task – or problem – centered
Motivation	External rewards and punishments	Internal incentives, curiosity

"

Goals of Self-Directed Learning

Merriam & Caffarella (1999) group the goals of self-directed learning into three aims "(1) to enhance the ability of adult learners to be self-directed in their learning, (2) to foster transformational learning as central to self-directed learning, and (3) to promote emancipatory learning and social action as an integral part of self-directed learning" (Merriam & Caffarella, 1999, p 290). Later, Merriam (2001) notes that the goals of self-directed learning differ according to the philosophic orientation and therefore assumptions of the writer. The first aim is most directly relevant to this research. Adult learners seek out learning experiences on their own, and the job of the educator is to help them (Merriam & Caffarella, 1999). This type of learning capitalizes upon the learner to take responsibility for their own learning, and is rooted in the humanistic philosophy of education. This first aim has been criticized by proponents of the third aim, mostly for focusing on instrumental learning and the individual learner. This research project falls prey to this criticism as it focuses primarily on instrumental learning of the individual learner.

The second articulated aim of self-directed learning is discussed in detail by Brookfield and Mezirow (Brookfield, 1985; Mezirow, 1985). This aim focuses on the learner having knowledge of alternative possibilities to the action that they take, insinuating that the learning is a self-motivated choice one makes after having complete knowledge of alternative possibilities. For example, an individual might choose to join Weight Watchers after considering the benefits and drawbacks of all of the other possible weight loss programs available in addition to the possibility of not losing weight. The criticism that adults are constrained by social institutions is not addressed in Knowles' work, as it focuses on the individual.

More recent analyses of the goal of self-directed learning have focused on its ability to minimize inequalities between social/political groups (Merriam, 2001). Regarding the topic of obesity, this would help to facilitate self-directed learning in adults with the intent of allowing them to free themselves from negative societal influences (e.g. discrimination, unequal salaries). Using the second aim, the learners would attain a complete understanding of the history of obesity and negative societal attitudes toward obese persons, ways in which people can and do lose weight, and what this would mean for them individually. With this information, individuals can then make a choice about how to proceed – taking action to change their situation (e.g. lose weight) or taking action to make societal changes.

Types/characteristics of adult learning

Mezirow (1985) distinguishes three types of adult learning: instrumental learning, dialogic learning, and self-reflective learning. Instrumental learning is based on cause and effect trials and can be built upon by past experience. Mezirow highlights the assumption that plagues andragogy, that adult learning happens as instrumental learning does, which he believes has skewed focus of adult education away from the other purposes of learning. A second type of learning, dialogic learning, involves symbolic interaction and the social process of constructing meaning through consensus of others or dialogue with others. Self-reflective learning is accomplished when the individual realizes that the ways in which he or she is proceeding are infringing upon how he or she wants to live and involves the reconsideration of maladaptive patterns (Mezirow, 1985). While instrumental learning is concerned with the learner and their interaction with the physical properties of the outside world, dialogic learning explores the learner's interaction with others in society and self-reflective learning has to do with the learner and themselves.

As Merriam & Caffarella (1999) stress, adult learning is a personal endeavor, which takes place in the context of each adult's life (Merriam & Caffarella, 1999). Individuals have different methods of achieving their goals, which could be proposed as a reason why confining adults to a particular structured way of dieting has not been effective. For some, counting calories/grams of carbohydrate/grams of fat/points may be helpful, but for others, this is not a feasible long-term strategy.

Criticisms of self-directed learning

Brookfield (1985) questions one of the primary assumptions of self-directed learning in adults: the assumption that adults are naturally self-directed (as opposed to children). Most of the research in self-directed learning has been conducted on middle-class, white, well-educated individuals, making generalizations to other groups a concern. Brookfield emphasizes the context-specific nature of learning in identifying problems with making this generalization (Brookfield, 1985). The adult is not completely removed from their environment and he or she relies on resources within that environment to facilitate learning. Thus, some reliance on external sources still exists in self-directed learning. This does not seem to conflict with Knowles' (1975) initial descriptions as he recognizes the utility of learners relying on 'helpers'. However, Brookfield (1985) and other theorists criticized Knowles' theory for lack of a critical edge considering the individual's placement in the social structures of society.

Research on self-directed learning

Merriam (2001) notes that Brockett and colleagues performed a content analysis and found a decline in the number of articles focusing on self-directed learning since the 1980s. Instead of suggesting that researchers and theorists move away from this area, she recommends looking at self-directed learning in new ways. In the past, the process of self-directed learning has been modeled linearly by some, but others have seen the process as taking more of an interactive approach (Merriam & Caffarella, 1999) such as proceeding without planning, or using a 'trial-and-error' approach. A more recent model, proposed by Garrison (1997) "integrates self-management (contextual control), self-monitoring (cognitive responsibility), and motivational (entering and task) dimensions to reflect a meaningful and worthwhile approach to self-directed learning." (Garrison, 1997, p 18)

There is a paucity of research on self-directed learning with regard to weight loss. Harris & Hallbauer (1973) incorporated self-directedness in their weight loss program by having one group of participants use a contract system. The contract allowed subjects to choose a reasonable amount of weight to lose, and to deposit a lump sum of money which would be returned to them at their chosen rate of X$ per pound lost. After 12 weeks the intervention using self-control strategies and the contract system did not produce a significantly different effect from the other two interventions; however, at a 7 month follow-up, both behavioral self-control and contract system interventions (one emphasizing exercise and eating behavior, the other emphasizing eating behavior) suggested a lasting effect on maintenance of loss. The authors attributed this to participants continuing self-control procedures such as keeping food logs (Harris & Hallbauer, 1973). Though not peer-reviewed, Courtney and Rahe discuss findings from their qualitative study in a book chapter (Courtney & Rahe, 1992). These researchers chose to focus on weight loss as an example of personal change by interviewing females that had participated in a program to lose weight in the past five years (n = 13). These interviews were part of a larger project aiming to theorize about learning in day-to-day life; much of the chapter focuses on separating and synthesizing learning concepts. Concerning weight loss, the authors found that participants followed the weight loss program, adjusted the program to meet their own needs, or rejected the program (Courtney & Rahe, 1992).

More recently, Garrison critiqued the study of self-directed learning due to its emphasis on the social and external management of resources (task control) instead of the internal psychological dimensions (Garrison, 1997). Individuals using the CTM for weight loss each engage in an internal individualized process along with managing and seeking resources, making this group well-suited to contribute to both the self-directed learning and weight loss literature. The following study aims to investigate the process of self-directed learning in a natural setting and how technology can facilitate this process in adults interested in losing weight. Building off of the findings of Courtney and Rahe (1992), analysis of participants continuing with the CTM and those withdrawing from the study are analyzed separately.

Methods & Study Design

As part of a larger study (CHAPTER 2), obese and overweight adults aged 18 and over responded to an advertisement indicating that they were interested in losing weight. Participants were randomized to either a control group or an experimental group. Both groups attended an initial information session where they were presented with research-supported strategies for weight-loss. The session offered information regarding small changes that could be made to reduce caloric intake and lose weight; however, an emphasis was placed on participants finding strategies that worked for them. The only difference between the control group and the experimental group's initial session was that the experimental group received a scale and access to the 'Caloric Titration Method' (CTM) internet program, designed to visually assist weight loss. Participants were shown how to register using the site and how to enter their weights. The site provides a graph of the participant's weights plotted over time and prompts them to lose 1% of their body weight at a time using a horizontal green goal line. This method was employed until they achieved a maximum of 10% weight loss. The site also provided informational material (a sheet about the rationale behind the Caloric Titration Method, a copy of the presentation with audio that was given at the initial session). Also, participants were welcomed to email the study investigators or Registered Dietitian at any time with questions or to arrange a meeting to discuss anything nutrition or health related. These 'helpers' and resources were made available to the participants for the duration of the study.

Participants

Participants were over the age of 18, had a Body Mass Index (BMI) of at least 27.0 kg/m2, and were not pregnant or planning to become pregnant, diabetic, or having reported a history of an eating disorder.

Baseline participant characteristics can be found in Appendix 6.1 and were collected using a web-based survey. In this table, comparisons are made between individuals that participated in interviews about their ongoing experience of the program, those that participated in exit interviews, and participants that did not participate in an interview.

Interview Protocol

Two weeks prior to the 6 month study measurement time point, participants were emailed to remind them to meet the PI to be measured and fill out the biyearly online study survey. In addition, they were asked if they would be willing to participate in an interview about their experience in the study. The IRB-approved request for interview email can be found in appendix 6.2. The same procedure was followed at the 12 month study measurement time point. If participants volunteered to interview, a private meeting room was reserved or a public location was decided upon where they would be comfortable meeting and discussing their experience.

Finally, participants who informed the PI of their choice to withdraw from the study were asked if they would be willing to meet with the Principal Investigator for a final measurement and to conduct an exit interview about their experience. Again, a private meeting room was reserved or a public location was chosen that was comfortable for the participant.

Semi-structured interview guides were developed for interviewing participants and voluntary withdrawals about their ongoing experience in the program. Similar questions were asked in both interviews, and the semi-structured guides can be found in Appendix 6.2.

A consent form for either the ongoing participant interview or the exit interview was approved by the Institutional Review Board and can be found in Appendix 6.2. Once consent was obtained to audio-record interviews, interviews were conducted and recorded using an Olympus WS-400 S Digital Recorder.

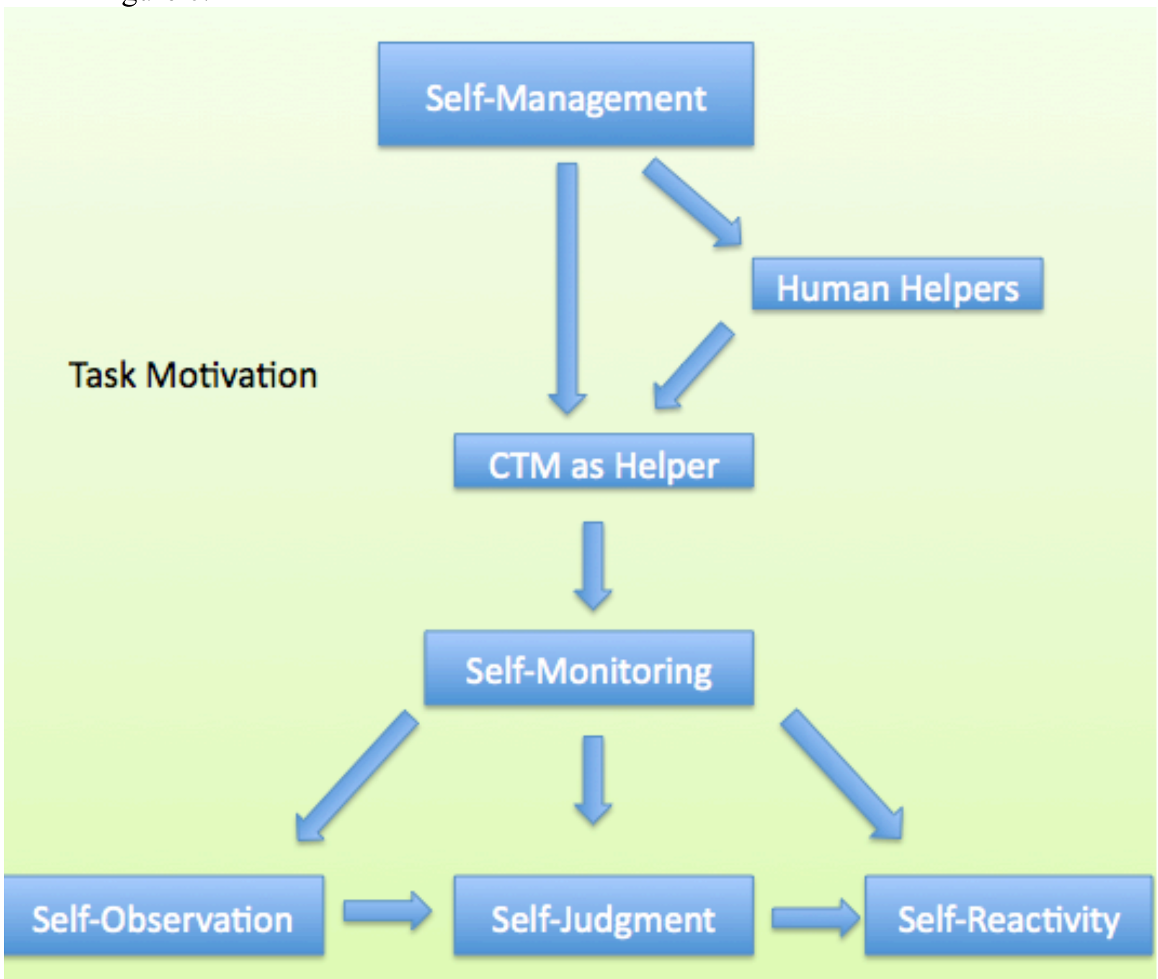
Data Analysis

Although the semi-structured interview guide used for ongoing participants was very similar to that used for people who withdrew from the study, these two participant experiences were treated and analyzed separately by research assistants trained in qualitative analysis because these two groups provided substantially different perspectives.

Interviews were transcribed into Microsoft Word Files and uploaded to Atlas Ti 7.0 for analysis. Analysis was directed towards determining how the CTM - frequent self-weighing and visual feedback - facilitated self-directed learning. Coding was driven by self-directed learning theory; a deductive or theory-driven approach was used for analysis (Spencer, Ritchie, & O'Connor, 2004). Specifically, Garrison's 1997 publication was used to develop a preliminary set of codes (Garrison, 1997). Transcripts were coded separately for continuing participants and people who withdrew from the study; this process was iterative and yielded more codes over time. Some emergent codes were distinct and applicable to one set of data. The process of reviewing transcripts and developing new codes proceeded until saturation was reached. Throughout weekly focused discussions, overarching themes emerged from code relationships. Conceptual diagrams were constructed to illustrate the relationships between themes, reflecting participant experiences.

Results and Discussion – Study Completers

Figure 6.1



Self-directed learning process used by participants using the CTM that continued with the study

The overarching theme of task motivation exhibited by completers indicated that the CTM program aided participants' achievement of a self-directed learning process similar to that outlined by Garrison (Garrison, 1997). Self-management served as the basis for learning as it involved the utilization of resources such as helpers. Participants in this study self-managed using the CTM as well as other human helpers. Self-management using the CTM aided in the process of self-monitoring, which can be broken down into three processes: self-observation, self-judgment, and self-reactivity. These processes worked in synergy as participants observed fluctuations in weight resulting from different behaviors, made judgments about the effect of those behaviors on their body weight, and then changed or continued their behaviors. Task motivation encouraged participants throughout the entire process to continue learning and weighing.

Due to the self-directed weighing process outlined by the CTM program, all participants who interviewed experienced self-management, or the opportunity to choose how they wished to carry out the learning process. Many participants exhibited self-management by developing specific routines or rituals to follow when weighing themselves. For example, some participants mentioned weighing themselves first thing in the morning before showering and after removing all clothing and jewelry. One participant mentioned keeping his scale on the same tile of the kitchen floor to create a sense of consistency and control. Many participants self-managed by finding ‘human helpers’ such as support groups or a Registered Dietitian to help develop strategies for weight loss. The amount and type of human helper influence differed by participant; some participants reported enrolling in Weight Watchers during participation in the study, and others reported working with their spouses to plan and prepare healthy lunches to bring to work. The individualization of needs was expected; the CTM was envisioned to assist in participants putting the necessary support systems in place for them to achieve their personal goals.

In addition to using ‘human helpers’, all study completers self-managed by using the CTM itself as a helper to aid in the process of self-monitoring. Many participants utilized the CTM to aid in instrumental learning through self-observation. These participants set up experiments for themselves in which they would alter their diet/exercise regime in a specific way, and then monitor the resulting changes in weight using the CTM. For example, some participants observed the effects of eliminating a snack between lunch and dinner, or saving half of their lunch-time sandwich for later. Other participants utilized a more passive form of discovery and simply weighed themselves everyday while maintaining their normal dietary patterns. These participants were then able to use self-observation, self-judgment, and self-reactivity to draw meaningful conclusions from their data. For example, female participants were surprised to learn that they retained 3-5 pounds of water prior to menstruation. Many participants observed the effect of high sodium foods on water retention in the body, as this was noticeable on the scale the following day.

Participants engaged in self-judgment and self-reactivity when they observed the effect of their behavior, made a judgment about that behavior, and then changed their behavior for a more desirable outcome. The following participant observed that increases in weight often occurred around the holidays. He/she then placed a negative judgment on her eating behavior and was able to change her behavior to decrease consumption at these times:*"I've learned that when it spikes it's holiday or family gathering but the thing is before I'd keep eating, now I can see it and know 'okay, you better stop'."*Similarly, another participant used this process to make a judgment about taking medication for arthritis pain: *"I finally became aware of, I take NSAIDS for arthritis and they're causing me to gain weight, they're causing me to, to retain water...Yeah I spiked up, the first night I took it I spiked up and then I, I took it for like*

2 days and I stayed up there I think and then I, I stopped taking it and I went right back down... Since I stopped taking it I don't have issues." This participant observed that the medication was connected to water retention, judged that water retention was undesirable because it placed more pressure on her joints, and then changed her behavior by discontinuing the medication.

For many participants, the overall process of self-management and self-monitoring allowed for a sense of positive perceived control. Such participants enjoyed being able to self-manage their learning process and felt increased control over their weight in alignment with weight loss goals. With regard to his/her weight, one participant exclaimed: *"I think it gives me a little more control just seeing it and being aware."* The CTM contributed to self-directed learning for most continuers by affording them task motivation throughout the entire learning process. The green goal line representing the participants' target weight for progression to the next stage of the program made participants feel that their overarching weight loss goal of 10% of their body weight was attainable through the accomplishment of 10 smaller goals of a reduction of 1% of their body weight.*"When I first started I, I took to it right away. I started losing pretty much on target with the goal line. I was really motivated, I was very driven, I liked seeing those results like every week or so I think it was or every 10 days, like where the line would drop down. And I'm like come on line - drop, you know I was really into that."*

For a handful of participants that continued with the program, participating in the CTM study facilitated a radical shift in mindset. For some, this change in mindset occurred immediately after enrolling in the CTM study. For others, the change occurred during the self-monitoring process. The defining characteristic of this change in mindset was that it entailed a shift in perspective about a particular behavior, making beneficial choices easier for the participant than they had been previously. *"Yeah and I've changed my thought process about that. You know going out I'm looking to say no I'm comfortable and I'm not going to do it anymore. It tastes really great but I'm comfortable about taking it home in a box and I anticipate that, I anticipate that now when I go out."* Most participants who experienced a radical change could not identify the cause of the change. Still it often resulted in high levels of self-perceived success in terms of progression through the weight loss stages of the study.

Table 6.2 Codes and sample quotes for study completers

CODE	SAMPLE QUOTE
Self-Management	*"Well I made it a routine pretty much. I have my laptop right on my kitchen table and my routine is to come out and turn on the coffee, turn on the computer, go to the scale. I have it right there. So I got a routine."*
Self-Observation	*"I don't know it's real pounds or if its water or what over the weekend and it's like okay. One thing I really noticed is that when I gain weight is when I eat Chinese food the sodium."*
Self-Judgment	*"It's very cyclical to say "oh this is not good, I'm down here at the bottom again" so I think it's been helpful in that way 'cause I all of a sudden I'm like holy cow I'm really not where I want to be like it puts that you know sort of red alarm."*
Self-Reactivity	*"The actual tracking of the weight? I think that that helps keep you mindful and, and I'll remember you know well I did have breakfast that day so I should skip this day or whatever."*
Task Motivation	*"So every day this graph is in my face and there's this little line that's just below where I am and it says you can do it you know. And I was so motivated by that line and getting that line, getting to that line."*
Human Helpers	*"Also I have a couple friends who sort of weekly we check in and that's been really helpful I think."*
Positive Perceived Control	*"I think what I've learned is it's not hopeless and I was beginning to get that point you know and, and that's what this has taugh me that this isn't hopeless, you can do it you know."*

Change in Mindset	*"No I just realized that things were going on at work and I was reaching for stuff and I'm like wait a minute, why am I doing this? It was just like a light, like came on and I, it just was like, now that I know what it is, I can help myself but before it's just unconscious, oh my gosh, I got to get this done or you know they need this or that and you reach for something and it's just very unconscious."*

Results and Discussion – Participants who Withdrew from the Study

Participants who ultimately dropped out of the study (n=10) engaged in a unique learning process guided by their interaction with the Caloric Titration Method. Despite these participants prematurely terminating their participation in the study, they were clearly able to implement some of the same strategies exhibited by participants who completed the study (Figure 1). Ultimately, a variety of extraneous factors, particularly stressors and negative reminders, acted to impede participants' progress by prompting an unwillingness to bear the responsibility of the frequent self-weighing process, culminating in study termination.

Participants who exited the study due to medical illness also exhibited a distinct learning process particular to the nature of their condition before dropping out (Figure 2). For these participants, self-weighing served as constant and overbearing reminder of their condition and the changes in their body that resulted from treatment. It is important to note that the relevant illnesses in the study were both typically associated with hormonal imbalances. Overall, negative sentiments associated with self-weighing resulted in a lack of motivation and an overwhelming disinterest in the level of control conferred by the Caloric Titration Method. A feeling of complete loss of perceived control ultimately lead participants to drop out of the study.

Throughout the study**,** instrumental learning provided participants with an introspective analysis of what worked for them by learning through trial and error what diet strategies could be realistically implemented in their lives. Often, instrumental learning involved a cognitive comparison between a participant's schedule and diet aids and/or helpers (for example, the Caloric Titration Method) that assisted in weight loss. Participants exhibiting instrumental learning thus developed working mantras and habits in order to enhance their progress.

Participants further used their self-observations to learn more about their own responsiveness to the program or to other weight-loss strategies. This form of self-monitoring lead to a better overall scope of the type of realistic weight-maintenance strategies that could be effective and a further openness to exploring new venues through which realistic weight maintenance could be achieved.

Through self-reflective learning, participants learned why the methods they had used to lose weight both before and during the program were not effective. This enabled them to concentrate on finding methods that were easier to implement for long-term weight-loss goals. Self-reflective learning embraces a heightened level of conscientiousness leading to an increased awareness of personal goals and a newfound open-mindedness to the implementation of new and better strategies.

The process of frequent self-weighing often enabled participants to realize that they were actually more frustrated than motivated by constant reminders of their weight. Frequent data was ignored due to high fluctuations. Thus, excessive control over the weighing process actually served to make these participants feel overwhelmed and dissatisfied by the inconsistency and lack of perceived positive results. This sentiment of negative perceived control imparted by the process of self-weighing served to detract from participants' progress and reduce motivation.

Participants who exhibited an antithesis of motivation also perceived the self-weighing process as being a burdensome and a frustrating stressor. These participants' expectations were not met by the results they witnessed through scale readings, and so they felt inadequate and unmotivated as they continued through the program.

In the absence of self-monitoring, participants made efforts to distance themselves from the frequent self-weighing process, preventing useful implementation of the data provided by the weigh-ins. Instead of using the knowledge gained to promote goal-setting, the participant ignored the recorded weights to prevent him/herself from feeling dejected by an underwhelming result. Participants who exhibited this form of learning tended to perceive the self-weighing process as being burdensome and serving as an unmanageable stressor.

Participants who rejected responsibility for their weight control were extremely put off by being reminded that they were not achieving what they perceived to be positive results. Participants tended to be sensitive to negative results, or results that did not coincide with their confidence in their health. The process of weighing had a negative impact on their mood, and so responsibility for the results was diffused rather than internalized to prevent feelings of failure.

For participants with medical illnesses linked to weight-gain, the Caloric Titration Method led to mental anguish as weighing served as a constant reminder of the negative impacts of their medical illnesses. Such participants learned that weighing took their focus away from their health and also gave them a psychologically debilitating negative perception of their illness. Table 6.1 provides an explanation of the codes used throughout analysis using relevant quotations to illustrate their connection to learning.

Table 6.3 Codes and sample quotes for participants who withdrew from the study

CODE	SAMPLE QUOTE
Instrumental Learning	*"I pretty much had a good way of managing my schedule where I could run, I could leave work for classes at Helen Newman and stuff like this, I knew what time I ate in the morning, what time I ate lunch and what time I ate dinner."*
Self-Monitoring	*"So I think I have to get to motivating myself towards weight loss with more a goal setting. I found that successful in the past… I just set a time period when I know I don't have many stressors and I can set that aside like vacation."*
Self-Reflective Learning	*"Losing weight slower is easier… when I was trying to lose weight it was like oh I can't eat this because it's going to go over this amount of calories or it's this. My whole day was consumed with that. This program I wasn't consumed with that at all."*
Negative Perceived Control	*"But unfortunately you know I can be good like that for a while but then when I started seeing the results not being there, it's frustrating. And then when I kept seeing the weight inching up even though it would go down a little bit and it would inch back up, I found that really frustrating."*
Antithesis of Motivation	*"But certainly having to look at the heavy weight was just a downer and it's not something I really needed to do at certain times you know because there's other stressors in my life and I'm just like you know I'm not very good at recording, you know I wasn't very good at trying to record all the weights. I thought that was a little more onerous than I'm personally able to do."*
Absence of Self-Monitoring	*"Looking at my scale. I can't like I, it caused me, I felt stressed out about it. It felt like one more thing in my life that I was going to need to manage and I didn't want to manage it right now. That's what happened. I was like this is reminding me of something that I'm not doing and I don't want to be reminded of this."*
Rejection of Responsibility	*"Yes, yes. And like and also just you know in general looking at, I know when I'm feeling healthy. Like I know when I'm doing the right things and I also know when I'm doing the wrong things but I think I don't like to be reminded of it."*
Loss of Perceived Control Due to Medical Issues	*"When I started the program it was going really good. Like I was losing really good actually consecutively. And then like I told you I had a Hysterectomy which has totally thrown my system off. And I gained a significant amount of weight and it got to the point where it was like weighing myself every morning was like a constant reminder… it got to the point where I'm like I'm not even going to look at it anymore because it started to become like a mental issue."*

Figure 6.2

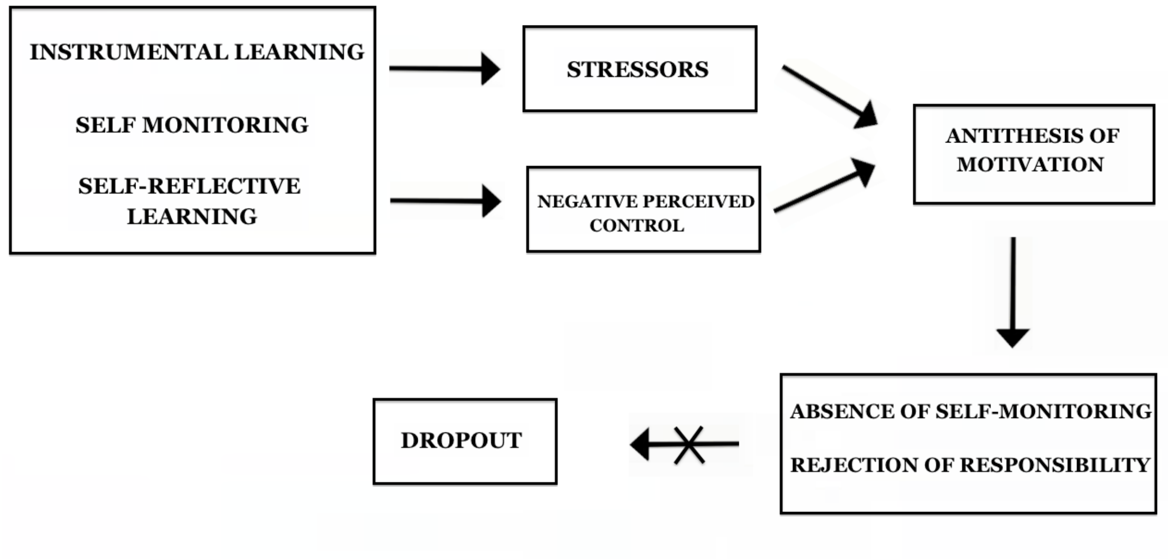


Figure 6.2 illustrates processes engaged in by CTM participants that withdrew from the study. Although participants ultimately dropped out of the program, they initially demonstrated instrumental and self-reflective learning and engaged in self-monitoring strategies similar to participants who completed the study. Ultimately, either extraneous "stressors" or a developing sentiment of negative perceived control lead participants to lose the motivation to continue. Lack of motivation lead participants to discontinue the process of self-monitoring and deny the sense of responsibility necessitated by the program. Participants whose learning followed this sequence ultimately dropped out of the study.

Figure 6.3

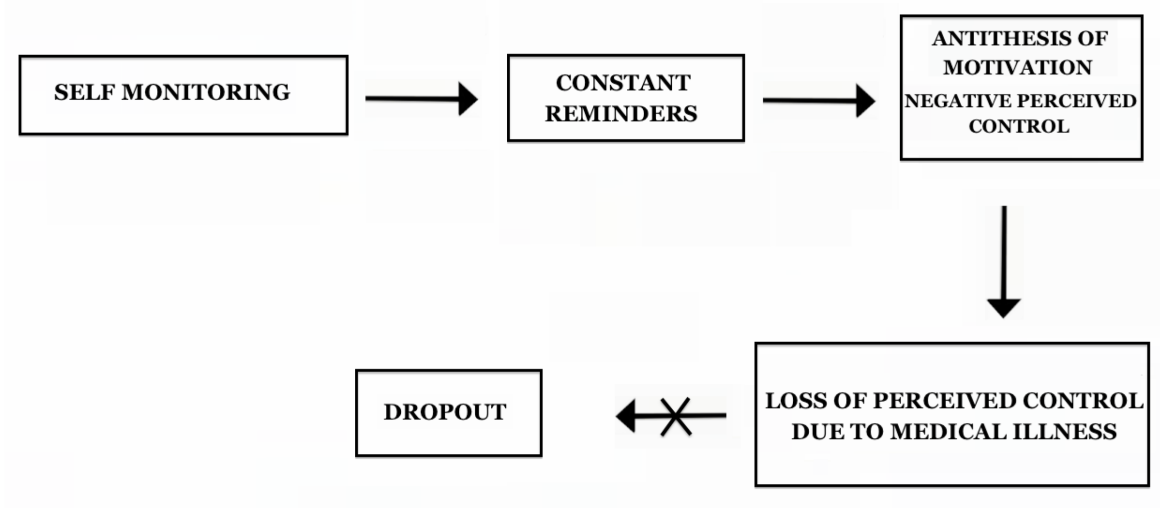


Figure 6.3 illustrates the learning process for dropouts who experienced medical complications during the study. Participants felt that the self-weighing process served as a constant reminder of their condition, which often involved hormonal imbalances that affected weight. This prompted a lack of motivation and an overwhelming disinterest in the frequent viewing of body weight promoted by the Caloric Titration Method. This culminated in a loss of perceived control over weight due to the interaction between the medical illness and frequent self-weighing, leading the participant to drop out of the study

Overall Discussion & Conclusions

A self-directed learning process was observed in individuals actively participating and withdrawing from a study involving self-weighing and visual weight feedback. Though both study completers and participants that dropped out of the study engaged in self-directed learning, often exemplifying the same concepts (e.g. instrumental learning) as part of their learning process, this lead to a positive sense of control over weight in completers and a lack of sense of control for participants who withdrew from the study. There are many other factors (medical illnesses, support of family members) that were not taken into account that could have accounted for the difference in sense of control. Ultimately, it seemed that the Caloric Titration Method, a technique of frequent self-weighing and visual internet feedback of body weight over time, facilitated a self-directed learning process in both participants that continued with the intervention and those that withdrew from the study.

Though published qualitative research on self-weighing as a weight loss strategy is nonexistent, others have evaluated weight loss as a behavior change from the participants' perspective. Falk, Bisogni, and Sobal (2000) characterized participants in a weight loss program to improve heart health into three separate behavior change processes (Falk, Bisogni, & Sobal, 2000). The conceptual model that Falk and colleagues arrived at was similar to the transtheoretical model (TTM) in terms of implications for practice – identifying a participant's stage and treating based on this information. The utility of the TTM approach is questionable. Quantitatively, Jeffery did not find stage of change to be predictive of successful weight loss in women (Jeffery, French, & Rothman, 1999). It is possible that stages characterized by readiness or transition through behavior change describe more of an attitude of the individual than an objective weight change. It is also possible that placing findings from qualitative studies into a quantitative framework and testing them for predictive value is not appropriate given the dissimilar aims of each type of research.

Acknowledging the limitations of this study, the sample was fairly homogenous in racial and ethnic identity. Participants were recruited through a wellness program at a university, limiting findings to these types of populations. Since interviews were voluntary, the data draws from participants that were willing and able to conduct an interview. It is possible that participants who volunteered to interview had a different experience than participants who did not volunteer, though on the measured variables reported in Appendix 6.1, this was not evident. Since adults comprised the participant population, it is important that these results be considered within the context of adults and self-directed learning as other groups may have different experiences with self-weighing.

Although this study did utilize the method of a contract system to help participants self-direct weight loss, it is unclear to what extent the choices of the participants to engage in self-control behaviors were directed by them versus directed by the graduate student running weekly meetings. In addition, the process of engaging in self-directed learning about how to lose weight was not described. Finally, this study falls prey to the limitations noted by Merriam & Cafarella (1999) concerning overemphasis on quantitative positivist paradigms (Merriam & Caffarella, 1999).

Despite these limitations, this research provides a rich understanding of how adults use self-weighing to facilitate self-directed learning during a weight loss intervention. Because the intervention requires minimal cost and time, it is important to investigate strategies such as this one for population use. Additionally, engaging in an active learning process compared to a passive instruction-following approach may be more sustainable as it may allow for the individual to figure out what works for them long term. Future studies assessing how self-weighing and visual displays of an individual's weight facilitate a self-directed learning process in diverse populations and age groups are necessary to gain a more robust understanding of how self-weighing works.

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APPENDIX 6.1 Characteristics by interview type

Baseline Characteristics				
	Exit Interviews	Interviews	No interview	p-value diff[a]
Age (years)	47.5 ± 12.3 (n = 10)	46.9 ± 8.5 (n = 47)	46.4 ± 10.2 (n = 86)	0.921
BMI (kg/m^2)	33.4 ± 5.5 (n = 10)	33.6 ± 5.0 (n = 50)	33.4 ± 5.2 (n = 82)	0.967
Body Weight (kgs)	88.1 ± 15.3 (n = 10)	93.6 ± 14.5 (n = 50)	94.5 ± 19.0 (n = 89)	0.547
Body Weight (lbs)	194.2 ± 33.8 (n = 10)	206.3 ± 32.0 (n = 50)	208.3 ± 41.9 (n = 89)	0.547
Height (in)	63.9 ± 2.6 (n = 10)	65.7 ± 3.0 (n = 50)	65.9 ± (4.2) (n = 82)	0.267
Education (years) *Highest level of education completed (select one): 1st grade (1), 2nd grade (2), 3rd grade (3), 4th grade (4), 5th grade (5), 6th grade (6), 7th grade (7), 8th grade (8), 9th grade (9), 10th grade (10), 11th grade (11), 12th grade/finished high school (12), one yr of college (13), two yrs of college (14), three yrs of college (15), four yrs of college (no degree) (16), college degree (17), masters degree (18), doctorate degree (19)*	15.4 ± 2.5 (n = 10)	15.9 ± 2.1 (n = 49)	16.0 ± 2.2 (n = 87)	0.744
Ethnicity: % White	100%	98%	83.5%	0.014
In the past year, how many times have you tried to lose weight? (choose one) *(0 (0); 1-2 (1); 3-4 (2); 5-6 (3); 7-8 (4); 9-10 (5); >10 (6))*	1.6 ± 1.8 (n = 10)	1.4 ± 1.3 (n = 49)	1.7 ± 1.4 (n = 88)	0.571

In your lifetime, how many times have you tried to lose weight? (choose one) *(0 (1);1-5 (2); 5-10 (3); 10-20 (4); 20-50 (5); 50-100 (6); > 100 (7))*	3.6 ± 1.7 (n = 10)	3.6 ± 1.5 (n = 47)	3.6 ± 1.3 (n = 88)	1.000
How important is it for you to lose weight? *(Not at All Important (1) Not Very Important (2) Somewhat Important (3) Very Important (4) Extremely Important (5))*	3.9 ± 0.9 (n = 10)	3.9 ± 0.7 (n = 48)	4.1 ± 0.7 (n = 88)	0.635
Are you currently on a diet? *(Yes/No)*[d]	10.0%	18.4%	19.5%	0.762
Have you attempted to diet in the past? *(Yes/No)*[d]	90.0%	89.1%	93.2%	0.709
Control *On a scale of 1 to 10, how much do you feel in control of your weight (1 being not in control at all, 10 being in full control)?*	3.4 ± 1.4 (n = 10)	4.8 ± 1.9 (n = 49)	4.11 ± 2.0 (n = 87)	0.044
Restraint (TFEQ)	9.4 ± 4.5 (n = 10)	10.1 ± 4.0 (n = 49)	9.6 ± 3.5 (n = 87)	0.748
flexible control (restraint)	2.9 ± 1.7 (n = 10)	3.1 ± 1.7 (n = 49)	2.8 ± 1.4 (n = 87)	0.635
rigid control (restraint)	3.2 ± 1.9 (n = 10)	3.1 ± 1.6 (n = 49)	3.1 ± 1.8 (n = 87)	0.988
Disinhibition (TFEQ)	8.6 ± 4.3 (n = 10)	10.2 ± 3.0 (n = 49)	10.1 ± 3.2 (n = 87)	0.306
Hunger (TFEQ)	5.2 ± 4.0 (n = 10)	7.0 ± 2.7 (n = 49)	6.5 ± 3.0 (n = 86)	0.201
Weight Locus of Control (WLOC)	11.1 ± 3.4 (n = 9)	8.0 ± 2.6 (n = 49)	9.0 ± 2.8 (n = 85)	0.006
Self Mastery	18.9 ± 2.4 (n = 10)	18.8 ± 2.9 (n = 49)	19.2 ± 3.1 (n = 84)	0.715
Quality of life – Physical Functioning (PF)	77.5 ± 22.7 (n = 10)	82.9 ± 17.8 (n = 50)	83.4 ± 18.7 (n = 87)	0.643
Quality of life – Role Physical (RP)	88.8 ± 17.4 (n = 10)	81.5 ± 18.5 (n = 50)	83.7 ± 19.1 (n = 87)	0.507
Quality of life – Bodily Pain (BP)	67.4 ± 22.7 (n = 10)	65.7 ± 21.2 (n = 50)	72.5 ± 19.0 (n = 87)	0.147
Quality of life – General Health (GH)	65.4 ± 17.7 (n = 10)	67.1 ± 20.8 (n = 50)	61.3 ± 18.5 (n = 87)	0.237

Quality of life – Vitality (VT)	53.1 ± 17.0 (n = 10)	51.5 ± 16.2 (n = 50)	49.3 ± 16.9 (n = 87)	0.643
Quality of life – Social Functioning (SF)	73.8 ± 37.0 (n = 10)	79.0 ± 23.1 (n = 50)	80.0 ± 23.3 (n = 87)	0.739
Quality of life – Role Emotional (RE)	75.0 ± 30.9 (n = 10)	82.3 ± 19.7 (n = 50)	78.7 ± 25.1 (n = 87)	0.562
Quality of life – Mental Health (MH)	68.5 ± 22.9 (n = 10)	73.0 ± 14.9 (n = 50)	67.7 ± 18.3 (n = 87)	0.241
Quality of life – Physical Component Summary (PCS)	50.5 ± 12.4 (n = 10)	49.2 ± 8.3 (n = 50)	50.8 ± 7.3 (n = 87)	0.543
Quality of life – Mental Component Summary (MCS)	44.3± 17.0 (n = 10)	47.3 ± 9.3 (n = 50)	44.6 ± 12.1 (n = 87)	0.400

[a] p-value for the difference between sample that participated in exit interviews, sample that participated in interviews about the CTM program, and sample that did not participate in interviews. One way ANOVA.
[b] mean ± standard deviation
[c] n may vary because of different data collection mechanisms (body weight taken in person, age reported via online survey)
[d] For questions with yes/no answers, the percentage that reported ‘yes’ is shown; the p-value column displays the p-value of the chi-square statistic for a two tailed-test
[e] when the expected cell count is less than 5, the chi-squared statistic cannot be calculated

APPENDIX 7.1 Did more contact (through interviews or meeting with study Registered Dietitian (RD)) influence outcomes?

Whether the initial session was in a large group and Professor Levitsky spoke in person or a smaller group and the recording was played did not make a difference in results in any of the analyses performed.

All participants were invited to meet with an RD voluntarily. Ten of these meetings took place, lasting between 30 minutes (1 meeting) and 2 hours. The majority of the meetings lasted an hour. An additional variable called 'RDmeet' was created to indicate whether or not the participant met with the RD.

In addition, interviews were offered at 6 months and 12 months for control and experimental participants. This was also voluntary. An additional variable called 'interview' was created to indicate whether or not the person participated in a face to face interview. If more than one interview was conducted on a participant the value was changed to '2'. Exit interviews were also conducted when participants were willing but these were not included in this count as they were at the end of participant's time in the program and were accounted for by a different variable (status). Fifty-three total participants had interviewed, two of these had interviewed twice.

Contact' was a variable created by combining the RDmeet and interview variables. A total of 58 participants had a nonzero count for this variable. Seven participants had 2 contacts (e.g. interview and RD meeting).

Since the interviews were offered at 6 and 12 months, the change scores over year 1 would be of interest. RD meetings; however, could have happened at any point throughout the two years. The majority occurred in the first year.

For categorical variables, chi-squared tests were used to determine if there were a disproportionate number of people having face contact between treatment groups or genders. A significantly greater proportion of participants in the experimental group had contact in the form of interviewing or an RD meeting as compared to the proportion of participants that had contact in the form of interviewing or an RD meeting in the control group ($p = 0.003$; 2-sided test). There was no statistically significant difference in the proportion of males and females that had contact in the form of interviewing or an RD meeting ($p = 0.108$).

Crosstabs

		Treatment Group		Total
		control	experimental	
contact	no	50	41	91
	yes	18	40	58
Total		68	81	149

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	9.012[a]	1	.004		
Continuity Correction[b]	8.030	1	.007		
Likelihood Ratio	9.186	1	.004		
Fisher's Exact Test				.007	.003
Linear-by-Linear Association	8.108	1	.004		
N of Valid Cases	149				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 26.47.
b. Computed only for a 2x2 table

Crosstab
Count

		gender		Total
		female	male	
contact	no	71	20	90
	yes	51	7	59
Total		122	27	149

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	2.344[a]	1	.126		
Continuity Correction[b]	1.724	1	.189		
Likelihood Ratio	2.451	1	.117		
Fisher's Exact Test				.190	.093
Linear-by-Linear Association	2.328	1	.127		
N of Valid Cases	149				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 10.51.
b. Computed only for a 2x2 table

For continuous variables, independent 2-tailed t-tests were used to compare means for those who did and those that did not have personal contact. If the p-value of Levene's test for equality of variances was greater than 0.05, the row displaying results for equal variances not assumed was removed. If the significance value was less than or equal to 0.05, the equal variances assumed row was removed.

T-Test

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Bodily Pain change over yr1	Equal variances assumed	1.169	.282	-1.163	119	.247	-4.71033	4.05076	-12.73125	3.31059
Bodily Pain change over 2 years	Equal variances assumed	.136	.713	-2.178	111	.032	-9.23005	4.23796	-17.62784	-.83225
Control change over yr1	Equal variances assumed	.149	.700	-.658	117	.512	-.32306	.49129	-1.29603	.64991
Control change over 2 years	Equal variances assumed	.928	.337	1.033	110	.304	.49818	.48237	-.45776	1.45411

Disinhibition change over 2 years	Equal variances assumed	1.162	.283	-.416	110	.678	-.24965	.60018	-1.43907	.93977
flexiblecontrol_change	Equal variances assumed	.571	.451	1.125	110	.263	.40094	.35623	-.30503	1.10690
Self efficacy change over 2 years	Equal variances assumed	.262	.610	-.547	111	.586	-.42967	.78604	-1.98725	1.12791
General Health change over yr1	Equal variances assumed	.105	.746	.904	119	.368	2.26826	2.51048	-2.70273	7.23926
General Health 2yrchange	Equal variances assumed	.533	.467	1.826	111	.071	5.14187	2.81589	-.43800	10.72174
Hunger change over 2 years	Equal variances assumed	.058	.810	.264	109	.792	.15543	.58827	-1.01050	1.32137
Self Mastery change over 1 yr	Equal variances assumed	1.380	.243	.884	114	.379	.45093	.51010	-.55956	1.46143

Self Mastery change over 2 years	Equal variances assumed	1.340	.250	-.226	106	.822	-.13651	.60415	-1.33430	1.06128
Mental Component Score change over yr1	Equal variances assumed	.052	.821	-1.555	119	.123	-3.32517	2.13887	-7.56034	.91000
Mental Component Score change over 2 years	Equal variances assumed	.198	.657	.657	111	.512	1.40666	2.13947	-2.83284	5.64616
Mental Health change over yr1	Equal variances assumed	.062	.804	-1.414	119	.160	-4.61045	3.26166	-11.06886	1.84797
Mental Health change over 2 years	Equal variances assumed	.000	1.000	.931	111	.354	3.14325	3.37587	-3.54627	9.83277
Physical Component Summary change over yr1	Equal variances assumed	.004	.949	-.214	119	.831	-.32383	1.51384	-3.32139	2.67373
Physical Component Summary change over 2 years	Equal variances assumed	.039	.843	-1.311	111	.193	-1.82191	1.38964	-4.57558	.93175

Physical Functioning change over yr1	Equal variances assumed	.013	.911	-.660	119	.510	-2.03086	3.07544	-8.12054	4.05882
Physical Functioning change over 2 years	Equal variances assumed	.167	.684	-.038	111	.970	-.12754	3.36794	-6.80133	6.54625
Role Emotional change over yr1	Equal variances assumed	.145	.704	-.890	119	.375	-4.13340	4.64543	-13.33182	5.06502
Role Emotional change over 2 years	Equal variances assumed	.094	.760	.314	111	.754	1.35156	4.29973	-7.16864	9.87177
Restraint change over 2 years	Equal variances assumed	.981	.324	1.364	110	.175	1.09807	.80496	-.49717	2.69331
Rigidcontrol change over 2 years	Equal variances assumed	.839	.362	.590	110	.556	.21449	.36356	-.50600	.93499
Role Physical change over yr1	Equal variances assumed	.078	.780	-.824	119	.412	-3.57323	4.33581	-12.15856	5.01210

Role Physical change over 2 years	Equal variances assumed	.004	.950	-1.230	111	.221	-4.72562	3.84144	-12.33770	2.88646
Social Functioning change over yr1	Equal variances assumed	1.964	.164	-2.271	119	.025	-9.43564	4.15535	-17.66366	-1.20763
Social Functioning change over 2 years	Equal variances assumed	2.390	.125	-.369	111	.713	-1.59799	4.33009	-10.17836	6.98238
Vitality change over yr1	Equal variances assumed	.007	.935	-1.818	119	.072	-5.66852	3.11771	-11.84191	.50486
	Equal variances not assumed			-1.808	98.757	.074	-5.66852	3.13547	-11.89017	.55313
Vitality change over 2 years	Equal variances assumed	1.653	.201	-.295	111	.769	-1.03503	3.51098	-7.99227	5.92221
Weight (lbs)	Equal variances not assumed			.402	143.911	.688	2.4415	6.0718	-9.5599	14.4429
Change in WLOC over yr1	Equal variances assumed	.072	.790	-.461	115	.646	-.23641	.51300	-1.25257	.77975

	Equal variances assumed	.031	.861	-1.440	109	.153	-.81515	.56596	-1.93687	.30656
Change in weight over yr1	Equal variances assumed	.006	.940	-.292	133	.770	-.6017	2.0584	-4.6731	3.4697
Change in weight over 2 years	Equal variances assumed	.184	.669	-1.735	118	.085	-4.6277	2.6671	-9.9092	.6539

In addition, any variables showing a significant difference between means for the more vs. less contact groups are highlighted. The only two variables that indicate a significant difference between participants with more face time as compared to those with less are Bodily Pain over 2 years and Social Functioning over the first year of the study. These two findings could easily be due to a Type I error – rejecting the null hypothesis when it is actually true (the null hypothesis is that the means for both contact groups are equal). If a Bonferroni correction was applied to the significance value to adjust for the number of comparisons made, neither of these would remain significant.

On the other hand, it would logically make sense that Social Functioning may increase more in a group that has more contact. For this reason, the means were explored further. Change is calculated as social functioning at the end of one year minus social functioning at baseline.

No extra meetings or interviews
Descriptive Statistics[a]

	N	Minimum	Maximum	Mean	Std. Deviation
Social Functioning change over yr1	73	-50.00	62.50	-1.8836	20.48365
Valid N (listwise)	73				

a. contact = no RD meetings or interviews

RD meeting and/or interviews
Descriptive Statistics[a]

	N	Minimum	Maximum	Mean	Std. Deviation
Social Functioning change over yr1	48	-50.00	75.00	7.5521	24.96535
Valid N (listwise)	48				

a. contact = RD meeting and/or interviews

Thus, those that did not have extra meetings or interviews had a mean loss of social functioning score of 1.9 (SD = 20.5). On the other hand, those that attended an RD meeting and or interviewed had a mean gain in social functioning over one year of 7.6 (SD = 25). It is possible that a confounding variable, such as gregariousness is responsible for this difference. People that are more sociable could have been more likely to ask for a meeting or interview among other things and then perceive their social functioning as increasing.

Of note, for the primary dependent variable of interest, change in body weight, though there were no significant differences between contact groups, means were in the opposite direction than expected. Over the first year, the group with no individual meetings lost an average of 3.7 ± 12.2 pounds, whereas the group that did have an interview and/or met with the study RD lost an average of 3.1 ± 11.0 pounds (p for difference 0.770).
Over the 2 years of the study, the group with no individual meetings lost a mean of 7.9 ± 14.8 pounds, while the group that did have an interview and/or met with the study RD lost an average of 3.3 ± 13.7 pounds (p for difference 0.085).

Contact was also assessed as a covariate in the mixed models. Contact alone was never significant, but when running the mixed model and including a contact by time interaction, this term had a p-value of 0.045, indicating that people who had versus did not have additional contact's weight changed differently over the two years of the study. This interaction term was not significant when only looking at the first year of the study (time*contact p-value = 0.359). When investigating the mean weights at each time point; however, those without extra meetings lost more weight than those with meetings. Thus, it does not appear that extra meetings in the form of interviews and/or meetings with study RD impacted weight change in a favorable direction.

Thus, even if having individual meetings with the study interviewer and/or RD did influence change in Social Functioning or Social Functioning influenced desire to attend an interview and/or meet with study RD on an individual basis which then influenced perception of change in social functioning, it does not seem that these variables had a significant effect on the primary outcome of the study, change in body weight.

CHAPTER 7

OVERALL CONCLUSIONS

To conclude, the research discussed in this dissertation revolves around a central theme: frequent self-weighing. Chapter 1 reviewed the history and application of frequent self-weighing and lack of experimental evidence supporting self-weighing for weight loss. Self-weighing was found to be a strategy utilized by adults who successfully prevented weight regain after loss or weight gain, though most study designs did not allow for the conclusion that weighing was the unique factor that contributed to the success of those that weighed more frequently. Chapters 2 and 4 describe results from a study isolating self-weighing along with visualization of an individual's weight over time and show that this technique, the Caloric Titration Method (CTM), was effective in significantly reducing obese and overweight adult's weight as compared to a delayed control group over a one year period. This significant result was qualified by a gender interaction; males derived more weight loss benefit than females during this study. Furthermore, the CTM succeeded in preventing weight regain in the intervention group a year after their weight loss. Finally, the CTM effectively prevented age-related weight gain in women over a two year period.

The CTM allows individuals to operationalize their weight and engage in a self-directed learning process - exploring dietary and/or exercise behaviors to control their weight. Chapter 6 analyzed the self-directed learning processes engaged in by both study completers and those that chose to withdraw and found evidence of learning in both groups. Chapter 3 analyzed psychological factors measured repeatedly over the 2 year study and found that if individuals believed that they had control over their weight, a more internal weight locus of control, they were more likely to lose weight when using the CTM. Broader views of control, such as self mastery, were not related to weight loss or success using the program. Aspects of quality of life, mainly physical functioning and vitality, were associated with weight change over 2 years. Future research is necessary to delineate the characteristics that distinguish individuals that will be successful with a self-directed program such as the CTM.

Chapter 5 attempted to investigate a potential mechanism through which the CTM works: priming. The failure to find significant differences in self-reported eating behavior scores depending upon whether participants were weighed prior to filling out a questionnaire or after filling out a questionnaire does not necessarily condemn the priming hypothesis. Several cognitive connections need to be made over time and the individual must be aware of these connections for results to be evident on a psychological questionnaire. It is possible that the effect of the scale as a negative prime is subtle, and as others have shown, perceptible in consumption terms (calories or grams). It could also be that the strength of the scale as a priming stimulus was not sufficiently strong in magnitude to shift cognitions about eating. A weight history may be more compelling in leading the individual to rationalize changes in weight. More direct tests of the scale and weight history as prime would be instructional in further understanding the process through which weighing works to facilitate weight control in adults.

The weight loss achieved by the experimental group in Chapter 2 was relatively small. However, when placed in context with estimates of adult age-related weight gain being about a pound per year in the United States, a 5 pound loss (approximate average of experimental group's weight loss over year 1 (5.7 pounds) and the delayed control group's weight loss during their treatment year (4.2 pounds)) is substantial. It is believed that there are many factors that contribute to the weight gain observed over the past several decades; following with many changes at both the micro-level (as in, the individual, which this dissertation addressed) in concert with the macro-level (community based changes, government level changes, changes in the food system) changes will be necessary to reverse trends. The method of frequent self-weighing and visual feedback studied is practical for population level dissemination. Future research identifying which individuals this self-directed program works for (racial and ethnic groups, age groups, personality characteristics, other moderating variables such as restraint) may allow for healthcare practitioners to use this less intense approach with appropriate patients, leaving more time to work more intensely with those in need of additional support.