ELECTRONICALLY RECORDED SELF-WEIGHING IN BEHAVIORAL TREATMENT FOR WEIGHT LOSS

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Submitted to the Graduate Faculty of

School of Nursing in partial fulfillment

of the requirements for the degree of

Doctor of Philosophy

University of Pittsburgh

2015

UNIVERSITY OF PITTSBURGH

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Abstract

Background: Self-weighing is a recommended but understudied weight loss strategy.

Objectives: 1) Examine the mediating effects of adherence to energy intake (EI) and energy expenditure (EE) goals on the association between self-weighing and weight changes; 2) Identify self-weighing patterns and examine differences in adherence to EI/EE goals and weight changes across self-weighing patterns; 3) Explore participants' experience of daily self-weighing.

Methods: The study included two methodological approaches. In the quantitative component, we conducted a secondary analysis of self-weighing data from a clinical trial (SELF) and a longitudinal, descriptive study of behavioral treatment for weight loss (EMPOWER). Outcome weight was measured every 6 months in the project office. Adherence to self-weighing protocols was calculated using data from electronic scales in the participants' homes. Adherence to EI/EE goals was obtained from the self-monitoring data. Linear mixed modeling, mediation analysis and group-based trajectory modeling were used for analysis. In the qualitative component, we conducted three focus groups to explore participants' experience of daily weighing. Content analysis was used to identify themes.

Results: During the first six months of the SELF study, there was a significant mediation effect of adherence to EI and EE goals on the association between adherence to self-weighing and

percent weight change (indirect effect: b=-0.26, p=0.02; b=-0.23, p=0.02). Using EMPOWER study data, three patterns of self-weighing were identified: *high/consistent* (75.0% self-weighed ≥6 days/week regularly); *moderate/declined* (16.2% declined from 4-5 to 2 days/week); *minimal/declined* (8.8% declined from 5-6 to 0 days/week). The *high/consistent* group achieved greater weight loss than the other two groups at 6 months (10.19%, 5.45%, and 2.00%) and 12 months (9.90%, 5.62%, and 0.65%). Focus group data revealed reasons for daily self-weighing included feeling motivated, providing feedback for eating and exercise behaviors, and feeling in control. Reasons for not weighing daily included interruption of routine and weight gain. The main suggestion for future users of this strategy was learning to accept a normal range of weight fluctuation.

Conclusions: Findings suggest that the majority of participants were able to sustain a habit of daily self-weighing, which impacts weight changes directly and indirectly through changes in EI and EE.

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PREFACE

I would like to thank all of the individuals who have provided assistance during my journey to the PhD degree. While I cannot specifically name the many individuals who have supported me along the way. I would like to acknowledge those who have played a key role in my completing my doctoral research and dissertation.

First, I would like to sincerely thank the members of my dissertation committee for their invaluable feedback, inspirational guidance and consistent support. Thank you to Dr. Lora Burke, my mentor and Dissertation Chair, for generously sharing her experience, knowledge and data to support my dissertation. The opportunities she provided me to be involved in her NIH funded projects permitted me to extensively develop my research skills while observing her as a role model of an excellent research scientist. Thank you to Dr. Susan Sereika for her tremendous support and guidance on improving my advanced analytical skill, data interpretation and writing skills. Thank you to Dr. Cynthia A. Danford for her deeply thoughtful feedback and for her guidance for the focus group study. Thank you to Dr. Linda Ewing for generously sharing her expertise in behavioral interventions. Thank you to Dr. Martha Ann Terry for guiding me through the conduct of the focus group study step by step.

I would like to thank Dr. Lora E. Burke's research team members and staff for their support and sharing their experiences with behavioral interventions, project management, and data management. Especially, I appreciate Ms. Rachel Goode for her support as a facilitator for

the focus groups. Also, the Undergraduate Research Mentoring Program and the student assistant who performed transcription and coding of focus group data, specifically especially Ashley Mmori.

I would like to thank all the funding support that made my research possible, particularly the STTI Eta Chapter that awarded me the Ruth Perkins Kuehn Scholarship for the conduct of the focus group study and Newmeyer-Thompson Doctoral Student Award 2015 that supported dissemination of results. The NIH grants that supported the collection of data used for my secondary analyses and dissemination of results.

I want to thank my dear friends and family members both in China and in the United States. I have been so fortunate to have all of you in my life to share my failures and successes as well as my sorrows and joys. I want to thank my fellow PhD students who have been tremendously encouraging and who have been generously sharing their knowledge. All of you made my journey much more enjoyable and priceless! I would like to thank my parents for their incredible support throughout my life, especially for being open minded and accepting of my desire to explore opportunities for higher education abroad.

1.0 PROPOSAL

1.1 SPECIFIC AIMS

Self-monitoring of body weight has been recommended as a component of standard behavioral treatment (SBT) for weight loss (Cooper & Fairburn, 2001), a strategy also recommended by the Clinical Guidelines for Treatment of Overweight and Obesity of the National Heart, Lung, and Blood Institute (National Institute of Health. National Heart Lung and Blood Institute, 1998). According to self-regulation theory, motivation for behavioral change results from self-monitoring and the comparison of its resultant information against an ideal state, as well as the interplay among awareness, self-observation, recording, and self-evaluation (F. Kanfer & Goldstein, 1990). Regular self-weighing permits the individual to increase his or her awareness of weight and its relation to energy intake and expenditure (Butryn, Phelan, Hill, & Wing, 2007).

Recent cross-sectional studies have demonstrated that more frequent self-weighing is associated with successful weight loss (Klem, Wing, McGuire, Seagle, & Hill, 1997; Kruger, Blanck, & Gillespie, 2006; McGuire, Wing, Klem, & Hill, 1999) and lower body mass index (BMI) (Linde et al., 2007) in adults. More recent prospective, longitudinal studies have demonstrated that frequent self-weighing is associated with greater weight loss (Gokee-Larose, Gorin, & Wing, 2009; Lally, Chipperfield, & Wardle, 2008; VanWormer, Martinez, Martinson, et al., 2009; Welsh, Sherwood, VanWormer, Hotop, & Jeffery, 2009; Yaguang Zheng et al.,

2013), less weight regain (Sherwood et al., 2013; R. R. Wing, Tate, Gorin, Raynor, & Fava, 2006) and better weight gain prevention (French, Gerlach, Mitchell, Hannan, & Welsh, 2011; Gokee LaRose, Tate, Gorin, & Wing, 2010; VanWormer, Linde, Harnack, Stovitz, & Jeffery, 2012). Moreover, there has been no evidence that there are adverse effects of frequent self-weighing (Gokee-Larose et al., 2009; Kong et al., 2012; Welsh et al., 2009; Rena R. Wing et al., 2007). In fact, the data suggests that self-weighing could be an effective self-monitoring strategy that promotes better weight loss and maintenance (Levitsky, Garay, Nausbaum, Neighbors, & Dellavalle, 2006; Madigan et al., 2013b; Steinberg et al., 2013).

One of the methodological weaknesses identified in the reviewed studies was the use of a single question asking about frequency of self-weighing (Burke, Wang, & Sevick, 2011; VanWormer, French, Pereira, & Welsh, 2008). Self-report tends to provide an over-reporting (Daniels et al., 2011; Ross-Degnan et al., 2010) or recall bias (Stone et al., 2000) of self-weighing frequency. Thus, more objective measures of self-weighing frequency are needed to validate the association of this intervention strategy with weight loss. The literature reports only three studies that have used objective measures of self-weighing. Vanwormer and colleagues used a telemonitoring scale (Thin-Link, Cardiocom, LLC., Chanhassen, MN) that transferred weight data automatically to the research center through a telephone land line (VanWormer, Martinez, Martinson, et al., 2009). Gokee-LaRose reported using a scale that stores weight data for 31 days (Gokee-Larose et al., 2009). Steinberg et al. (2013) used a smart scale that displayed current weight and transmitted the data directly to a website (www.bodytrace.com) via a wireless cellular network (Steinberg et al., 2013). The limitations of these studies included small and homogeneous samples and short-term follow-up, which limits the generalizability of the

findings. Additional studies need to include the use of wireless scales with larger, more diverse samples.

An ongoing challenge is the wide range of adherence to self-weighing (from 53.8% to 100%) (Gokee LaRose et al., 2010; Gokee-Larose et al., 2009; Linde & Jeffery, 2011; Sherwood et al., 2013), suggesting that we need to identify betterstrategies to improve adherence to self-weighing. Moreover, little is known about the personal and environmental factors that may influence adherence to self-weighing, or the individual's perception and acceptance of this strategy. Thus, research exploring participants' perception and acceptance as well as barriers to daily weighing needs to be conducted.

In an attempt to fill these gaps, we proposed a study using qualitative and quantitative methods. The quantitative component of this project involved a secondary data analysis of self-weighing data that were collected by electronic scales in two longitudinal studies of behavioral treatment for weight loss. Individuals in the SELF (Lora E. Burke, P01NR010949) trial were provided a scale (Carematix, Inc., Chicago, IL) that stored data for 100 days and were instructed to weigh themselves at least three times per week or every other day. This scale provided a date- and time-stamp for each weighing episode. Participants brought the scale to the center every three months to upload their data. Participants in the EMPOWER (Lora E. Burke, R01HL107370) study were instructed to use a Wi-Fi scale for daily weighing at home that transmitted the data in real time to the study server.

The qualitative component of this project used focus group methodology to ascertain participants' perceptions and acceptance of daily weighing as well as their perceived benefits and barriers to daily weighing. We facilitated 3 focus groups, enrolling 6-12 participants for each group. The participants were those who completed the EMPOWER study.

Specific aims:

Primary Aim:

Aim 1: Describe adherence to the self-weighing protocol, which will be defined as the number of self-weighing events divided by the total number of days self-weighing was prescribed over a defined period of time.

Secondary Aims:

Aim 2: Explore the association between electronically recorded adherence to self-weighing and percent weight change.

Aim 3: a. Explore the mediating effect of adherence to the energy intake goals on the association between self-weighing and percent weight change.

b. Examine the mediating effect of adherence to the energy expenditure goals on the association between self-weighing and percent weight change.

Aim 4: Explore individuals' perception and acceptance of daily weighing as well as their perceived benefits and barriers to daily weighing.

1.2 BACKGROUND AND SIGNIFICANCE

1.2.1 Background

1.2.1.1 Prevalence of overweight and obesity

The prevalence of obesity has been at an epidemic level in the United States for over a decade (Flegal, Carroll, Kit, & Ogden, 2012; Samaranayake, Ong, Leung, & Cheung, 2012). Approximately two thirds of the adult population is either overweight (BMI of 25–29.9) or obese (BMI ≥30) (Main, Rao, & O'Keefe, 2010). Obesity is significantly associated with an array of diseases including cardiovascular disease, type 2 diabetes, osteoarthritis (Vincent, Heywood, Connelly, & Hurley, 2012), depression (Faith et al., 2011) and several cancers including endometrial, breast, and colon (Secord & Gehrig, 2012). In summary, the persistently high prevalence rates of overweight and obesity make it one of our most pressing public health concerns.

1.2.1.2 Standard behavioral treatment for weight loss

Standard behavioral treatment (SBT) remains the first line of treatment. SBT is comprised of group-based cognitive-behavioral intervention strategies, daily dietary and weekly physical activity goals, and self-monitoring of daily energy and fat intake and physical activity(R.R. Wing, 2004). However, long-term maintenance of weight loss is a significant challenge, demonstrated by the fact that most participants regain weight following intentional weight loss (Butryn, Webb, & Wadden, 2011; Katan, 2009). Individuals may regain up to 3 kg the first year

after termination of a weight loss intervention and possibly progress within 5 years to a complete regain of the weight that was lost (Blomain, Dirhan, Valentino, Kim, & Waldman, 2013). Because of the high recidivism rate, it is important and essential to identify strategies to improve weight loss maintenance.

1.2.1.3 Self-monitoring in weight loss treatment

Programs that target behavior change and weight loss maintenance are built on strategies that support the individual's ability to self-regulate behavior, which necessitates self-monitoring. More than two decades ago, support for the role of self-monitoring in weight control began to emerge, and self-monitoring is considered the centerpiece of SBT for weight loss (Baker & Kirschenbaum, 1993). Self-monitoring is a method of systematic self-observation, periodic measurement and recording of target behaviors with the goal of increasing self-awareness of the targeted behavior (F. H. Kanfer, 1970; Mary H. Wilde & Suzanne Garvin, 2007).

The theoretical basis for self-monitoring is provided by Kanfer's theory of self-regulation, which is based on social cognitive theory (F. H. Kanfer, 1970, 1985). Kanfer describes self-regulation as consisting of three distinct stages: self-monitoring, self-evaluation, and self-reinforcement (F. H. Kanfer, 1970). Self-monitoring is essential as the awareness of internal and external cues is the initial step in managing the behavior (M. H. Wilde & S. Garvin, 2007). Motivation for behavioral change results from reviewing the recording from self-monitoring of behavior and comparing progress made to a desired goal (F. Kanfer & Goldstein, 1990), as well as the interplay among self-observation, recording, awareness, and self-evaluation (M. H. Wilde & S. Garvin, 2007). Individuals cannot influence their motivation and actions well unless they pay deliberate attention to their own performance as well as the conditions under which they occur and their immediate and long-term effects (Bandura, 1998).

The empirical literature provides extensive evidence supporting the central role of self-monitoring in behavioral treatment for weight loss (Acharya et al., 2009; Burke, Wang, et al., 2011; M. W. Turk et al., 2012). A consistent and significant association has been found between self-monitoring and successful weight loss and weight maintenance since the late 1980's; more frequent self-monitoring is significantly associated with weight loss (Acharya, Elci, Sereika, Styn, & Burke, 2011; Baker & Kirschenbaum, 1993; Boutelle, Kirschenbaum, Baker, & Mitchell, 1999; Burke, Conroy, et al., 2011; Burke, Swigart, Warziski Turk, Derro, & Ewing, 2009; Burke, Wang, et al., 2011; Conroy et al., 2011; Cooper & Fairburn, 2001; Wang et al., 2012). Burke et al. have demonstrated that timing as well as consistency of self-monitoring is significantly related to improved outcomes (L. E. Burke et al., 2006; Burke et al., 2008). Traditionally, self-monitoring has focused on recording dietary intake and physical activity; however, more recently, self-weighing has been added to the treatment protocol (Burke, Wang, et al., 2011).

1.2.1.4 Self-weighing in weight loss treatment

Self-monitoring of body weight has been recommended as a component of standard behavioral treatment for weight loss (Cooper & Fairburn, 2001). The National Heart Lung and Blood Institute Clinical Treatment Guidelines recommend the inclusion of weight self-monitoring and view this strategy as critical for long-term maintenance (National Institute of Health. National Heart Lung and Blood Institute, 1998). Regular self-weighing permits the individual to observe changes in weight and become aware of specific situations or patterns of eating or physical activity and how they are related to changes in body weight (Butryn et al., 2007). These observations may motivate the person to sustain behavior changes that support positive outcomes, or take corrective action for those that may lead to weight regain (Welsh et al., 2009).

Earlier work suggested that self-weighing had no effect on weight loss (Heckerman, Brownell, & Westlake, 1978) and frequent self-weighing generated negative mood (e.g., depression, body dissatisfaction) (J. Ogden & Evans, 1996; Jane Ogden & Whyman, 1997). Subsequently, there was a common perception among clinicians and researchers in the weight control field that one should not recommend self-weighing as a weight loss strategy (Dionne & Yeudall, 2005). However, recent cross-sectional studies demonstrated that more frequent self-weighing is associated with successful weight loss (Klem et al., 1997; Kruger et al., 2006; McGuire et al., 1999) and lower BMI (Linde et al., 2007) in adults. Self-weighing began to be reconsidered as a useful strategy for weight loss and maintenance. A randomized clinical trial using an approach that was based on self-regulation theory reported that daily weighing was significantly associated with successful weight loss maintenance (R. R. Wing et al., 2006) and was not associated with negative psychological consequences (Rena R. Wing et al., 2007). More recently, there has been an increase in the number of prospective, longitudinal studies on self-weighing, which revealed that regular self-weighing was associated with greater weight loss (Gokee-Larose et al., 2009; Kong et al., 2012; Lally et al., 2008; Linde & Jeffery, 2011; Steinberg et al., 2013; VanWormer, Martinez, Martinson, et al., 2009; Welsh et al., 2009), less weight regain (Funk et al., 2010; Madigan et al., 2013a; Sherwood et al., 2013; Sherwood et al., 2006; R. R. Wing et al., 2006) and better weight gain prevention (French et al., 2011; Gokee LaRose et al., 2010; Jeffery & French, 1999; Levitsky et al., 2006; VanWormer et al., 2012). Also, regular self-weighing was not associated negative psychological outcomes in adults seeking behavioral weight loss treatment (Gokee-Larose et al., 2009; Kong et al., 2012; Steinberg et al., 2014; Welsh et al., 2009; Rena R. Wing et al., 2007).

However, one weakness of the reported studies was the method used to assess self-weighing. Most of the studies used self-reported methods and asked the participants about the frequency of self-weighing (e.g., daily, weekly). For example, some studies used a single question asking about frequency of self-weighing with response options being *never, about once a year or less, every other month, once a month, once a week, once a day, or more than once a day* (French et al., 2011; Gokee LaRose et al., 2010; Jeffery & French, 1999; Kong et al., 2012; Linde & Jeffery, 2011; Sherwood et al., 2013; Sherwood et al., 2006; VanWormer et al., 2012; Welsh et al., 2009). Wing and colleagues asked participants to indicate how frequently they weighed themselves during the past month using a 7-point scale ranging from several times a day to never (Rena R. Wing et al., 2007). Other studies used e-mail (Levitsky et al., 2006), a daily monitoring form (Lally et al., 2008), recording card (Madigan et al., 2013a), or website weight tracking (Funk et al., 2010). However, these self-report methods might not accurately reflect the actual weighing behavior. VanWormer (2008) conducted a literature review on self-weighing mainly using cross-sectional studies and suggested that more objective methods of assessing self-weighing frequency were needed to validate self-reported measures (VanWormer et al., 2008). Since that review in 2008, only three studies used electronic scales to objectively measure self-weighing behaviors (Gokee-Larose et al., 2009; Steinberg et al., 2013; VanWormer, Martinez, Martinson, et al., 2009). These studies used electronic scales that transmitted the weight data remotely to the research center (Steinberg et al., 2013; VanWormer, Martinez, Martinson, et al., 2009) or stored the data for later uploading of the data (Gokee-Larose et al., 2009).

One question not answered in the literature is the dose of self-weighing required for successful weight outcomes. In 2008, VanWormer suggested that weekly self-weighing seemed to be a reasonable strategy to endorse for adults (VanWormer et al., 2008). However, daily

(Gokee-Larose et al., 2009; Kong et al., 2012; Steinberg et al., 2013; Welsh et al., 2009; Rena R. Wing et al., 2007) or weekly (Madigan et al., 2013a; VanWormer et al., 2012; VanWormer, Martinez, Martinson, et al., 2009) weighing was reported in recently published studies. With the use of electronic scales becoming increasingly more common in weight loss treatment programs, daily weighing seems more feasible as a strategy to regulate diet and exercise behavior changes. Ongoing research continues to provide evidence that daily weighing led to better outcomes when compared to less frequent weighing (VanWormer et al., 2012; VanWormer, Martinez, Benson, et al., 2009; Welsh et al., 2009; Rena R. Wing et al., 2007). By viewing his or her weight each day, individuals can observe the small changes and relate this to current eating and physical activity behaviors, which in turn can support improved self-regulation of those and other lifestyle behaviors. In addition, the small changes in body weight may allow individuals to recognize the normal variability in their weight and factors in addition to energy balance that contribute to this variability. Realization of how body weight fluctuates over time also may encourage individuals to focus on their daily behaviors rather than solely on longer-term outcomes (e.g. weight loss).

Moreover, daily weighing might be a useful strategy to promote weight maintenance after weight loss, since previous research has found that reversing weight regain was rare but possible if individuals observed the weight regain early or addressed minor lapses (Phelan, Hill, Lang, Dibello, & Wing, 2003; R. R. Wing et al., 2006). Currently, however, the evidence does not support endorsement of an ideal self-weighing frequency or duration for recommended use of this strategy. Thus, much work remains to be done to determine the dose (i.e., frequency, duration, etc.) of self-weighing that is feasible and necessary to support weight management.

Moreover, no studies have reported patterns of self-weighing over an extended time period. Only four studies reported the adherence or frequency of self-weighing over a short

period of time. Gokee-Larose et al. reported that approximately 90% of participants weighed themselves daily at the end of the 10-week intervention, which decreased significantly at the 20-week follow-up (Gokee-Larose et al., 2009). This pattern of initial high level of adherence to self-weighing followed by a gradual decrease after approximately 3 months was reported by one other investigator (Linde & Jeffery, 2011). Another study by the same investigative group showed that the majority of participants weighed daily at 8 weeks in two treatment conditions (91% vs. 100%), then decreased at 16 weeks (61% vs. 90%) (Gokee LaRose et al., 2010). Sherwood et al. reported that overall participants weighed themselves daily 54% of the days but they did not report the pattern of self-weighing over time (Sherwood et al., 2013). Evidence has demonstrated that there is a gradual decline in adherence to self-monitoring of diet and exercise which worsens when the treatment sessions and contact with research staff/interventionist decreases in frequency (Burke, Wang, et al., 2011). It is unknown if the pattern of adherence to self-weighing is similar to or differs from that of self-monitoring of diet and exercise. Furthermore, little is known about the personal and environmental factors that may influence adherence to self-weighing, or the individual's perception and acceptance of this strategy. Research exploring participants' perception and acceptance as well as barriers to daily weighing also need to be conducted. This section was expanded to a systematic review, which was published in the journal Obesity (see Appendix A).

1.2.2 Significance and Innovations

1.2.2.1 Significance

It has been demonstrated that adherence to self-monitoring mediates the effect of the behavioral weight-loss intervention on weight loss outcomes (Acharya et al., 2009; Melanie W. Turk et al.,

2012). Therefore, it is important to explore the pattern of adherence to self-weighing and identify the barriers influencing adherence to self-weighing behavior. The proposed study is significant because the findings could:

- Provide a more accurate description of self-weighing patterns over time than self-report and how this is related to weight change as well as validate the findings using self-reported measures using an electronic scale to objectively measure self-weighing behavior.
- Help elucidate the underlying mechanism of how self-weighing may affect weight change by exploring the mediation effects of adherence to energy intake and expenditure goals on the association between self-weighing and weight change.
- Inform the development of strategies that support the use of this important component of the intervention and improve adherence to self-weighing, and ultimately, improve weight loss maintenance by exploring the participants' experience of daily weighing.
- Add to the knowledge pertaining to the broader domain of behavioral self-monitoring.
- Be applicable to the study of conditions using self-weighing as a behavior change strategy, such as self-management of chronic illnesses (e.g., congestive heart failure).

1.2.2.2 Innovations

The proposed study is innovative because it is the first study to:

- Examine electronically recorded self-weighing data during long-term standard behavioral treatment for weight loss. Therefore, the findings using an objective assessment method of self-weighing provide evidence for the association between self-weighing and weight management.
- Use qualitative methods to explore and describe participants' experience of daily weighing as well their perceived benefits and barriers to daily weighing in a weight loss intervention study. Thus, findings from this innovative approach can inform the development of strategies that support the use of this important self-monitoring intervention.

1.3 RESEARCH DESIGN AND METHODS

1.3.1 Quantitative Component

1.3.1.1 Study design

The quantitative component of the proposed dissertation included a secondary data analysis of self-weighing data that were collected by electronic scales in two independent longitudinal studies of behavioral treatment for weight loss. These studies include the SELF trial (PI: Lora E. Burke, P01NR010949) and the EMPOWER study (PI: Lora E. Burke, R01HL107370).

The SELF trial was a 2-group, single-center, 18-month clinical trial of adults seeking treatment for weight loss. The experimental group (SBT+SE) received a SBT weight loss intervention that was supplemented by individual sessions guided by self-efficacy theory and provided tailored, incremental goals for weight loss and accordingly, incremental calorie and fat

restrictions. The SBT group also received a SBT intervention to promote weight loss but had no individual sessions and had standard calorie and fat restrictions. Individuals in the SBT+SE group were provided a scale (Carematix, Inc., Chicago, IL) that stored data for 100 days and were instructed to weigh themselves at least three times per week or every other day. This scale provided a date- and time-stamp for each weighing episode. Participants brought the scale to the research center every three months for uploading the data. For this secondary analysis, we used the data only from the intervention group (n=58).

The EMPOWER study delivered a 12-month behavioral weight-loss intervention. The participants were encouraged to attend the 24 group-formatted treatment sessions that were held over the 12-month study. The EMPOWER study used a data collection method referred to as ecological momentary assessment (EMA), which permitted assessing individuals in their natural setting and in real time. The purpose of the study was to identify the triggers or antecedents of relapse-relevant events during weight loss, e.g., temptations and lapses, by daily assessments conducted in real time in the person's natural environment. Each participant was given a Wi-Fi scale (Withings, Inc., Issy-les-Moulineaux, France) that transmitted the weight to the self-monitoring server and to the project server in real time. The participants were instructed to weigh themselves daily at home during the 12-month weight loss intervention. The study completed enrollment with six cohorts (N = 151). For this secondary analysis, we proposed to use data from the first four cohorts (n=89).

1.3.1.2 Sample

For the SELF Trial, individuals whose BMI was between 27 and 44 kg/m^2 with one additional risk factor for cardiovascular disease were eligible. Participants were asked to reasonably assess whether or not they would be able to commit to an 18-month intervention. They were excluded if

they were planning a pregnancy or relocation that would prevent them from attending the sessions. To minimize attrition, individuals who participated in weight-loss treatment in the past five years prior to screening were not eligible. Assessments were conducted every six months throughout the studies as described below.

Eligibility criteria for the EMPOWER study were that individuals: (1) were ≥ 18 years of age, (2) had a BMI between 27 and 44, inclusive, and (3) had not participated in another weight loss program in the past 3 months. individuals were excluded if they: (1) had the presence of any condition that may confound study findings (e.g., diabetes, pregnancy, post bariatric surgery); (2) planned to become pregnant in next 12 months; (3) planned frequent travel, extended vacations or relocation in next 12 months; (4) were receiving current treatment for a serious mental illness; (5) reported alcohol intake ≥ 4 drinks/day; or (6) were unable or unwilling to use the smart phone for EMA data collection.

1.3.1.3 Measures

Socio-demographic data. The Socio-demographic and Lifestyle Questionnaire, a self-administered, standardized questionnaire developed by the Center for Chronic Disorders at the University of Pittsburgh, was used to assess sociodemographic factors at baseline.

Weight. A digital scale (Tanita Corporation of America, Inc., Arlington Heights, IL, USA) was used to measure weight at baseline, 6, 12, and 18 months. Participants wore light clothing and no shoes and had fasted overnight. For analyses weight was transformed into percent change relative to baseline level (t=0) to control the variability of baseline weight and to be consistent with other weight-loss intervention studies. That is, percent weight change was defined as ([weight$_t$ – weight$_0$] / weight$_0$) x 100%, t = 6, 12, 18 months.

Self-weighing. For the SELF study, participants were given a scale (Carematix, Inc.) at the start of the intervention and instructed to weigh at least three days/week or every other day. The scale date- and time-stamped each weighing episode, storing a maximum of 100 readings, which was uploaded every 3 months during a study visit. Self-weighing was analyzed as continuous (mean days/week) and binary variables (<3 days/week vs. >3 days/week). The outcomes were calculated as two forms over three six-month blocks of time*: the mean days of self-weighing per week*, and the *proportion of weeks adherent*: (number weeks of adherent to at least three days per week of self-weighing / total number of weeks) x 100%. For the EMPOWER study, participants were instructed to use a Wi-Fi scale for daily weighing at home that transferred data in real time to the study server. The scale date-stamped each weighing episode. Self-weighing was examined as continuous (mean days/week) and binary variables (daily weighing/week vs. non daily weighing/week). The outcomes were analyzed using the two forms over three 6-month blocks of time: *the mean days of self-weighing per week*, and *the proportion of weeks adherent*: (number weeks of adherence to daily weighing / total number of weeks) x 100%.

Adherence to the energy intake goal. We calculated adherence to energy intake goals on a weekly basis to allow for the strategy of banking calories. Adherence to the energy goal was calculated by dividing the total number of calories consumed per week by the weekly calorie goal, then multiplying by 100% to express the value as a percentage, e.g, if a participant with a daily calorie goal of 1800 (weekly goal = 12,600) reported consuming 10,500 total calories in a week, the level of adherence to the energy goal was calculated as 83.3% (10,500/12,600 × 100%). Based on the calculation of adherence to the energy intake goal, participants were categorized as adherent (reported consuming 85%–115% of the weekly goals) and non-adherent

(reported consuming <85% or >115% of the weekly goals) on a weekly basis. If a diary was not returned, adherence to energy intake goals was coded as non-adherent for that week. The reason that we provide a range for adherence to the calorie intake goal is that the self-reported intake of energy is not precise (requires counting every calorie consumed). Also, a person may save or bank some calories on one day so the person can exceed the goal for n a special occasion the next day. Additionally, some participants might under-report their calorie intake. If they did not report the complete calorie intake, they might also be non-adherent. Therefore, we provide a range for dietary adherence. For the analysis, we calculated the proportion of weeks the participant was adherent to the calorie goal by dividing the number of weeks adherent to the calorie goal by the total number of weeks in each six-month period.

Adherence to exercise goal. We calculated exercise adherence using the reported weekly minutes spent exercising divided by the weekly goal multiplied by 100%. For example, if a person who reported 140 minutes per week of exercise when the goal was 150 minutes per week, adherence to the goal would be 93% (140/150 × 100%). Since the exercise goal was increased over the first six weeks, the denominator was changed accordingly. Adherence to the goal was examined as a binary variable based on whether participants achieved the goal each time their diaries were submitted (adherent: ≥100% of weekly goal, nonadherent: <100% of weekly goal). Similarly, for the data analysis, we calculated the proportion of sessions the participant was adherent to the exercise goal as described above.

1.3.1.4 Statistical analysis plan

Statistical analyses were conducted using software of SPSS (version 22.0., SPSS, Inc., Chicago, IL), SAS (version 9.3, SAS Institute, Inc. Cary, NC), and Mplus (version 7.31, Muthén & Muthén, Los Angeles, CA) for Windows.

Sample Size Justification

The proposed study was a secondary analyses and the sample size was fixed (SELF: N=58; EMPOWER: N= 89). Thus, we calculated the smallest detectable effect given a desired level of power.

Aim1(SELF study): The PASS 12.0, repeated measures analysis using mixed models was used to detect the effect size of adherence to the self-weighing protocol over time. We used randomized block analysis of variance (ANOVA) to detect the smallest detectable effect at a desired power of .8. The significance level (alpha) was set at the traditional .05, the minimum power as 0.80, and sample size of 58 will achieve the smallest effect size of 0.245.

Aim1 (EMPOWER study): The PASS 12.0, repeated measures analysis (mixed models) was used to detect the effect size of adherence to the self-weighing protocol over time based on a randomized block ANOVA to detect the smallest effect. The significance level (alpha) was set at .05, the minimum power was 0.80, and sample size of 89 achieved the smallest effect size of 0.213.

Preliminary Analysis Procedures

Descriptive statistical analyses were conducted using SPSS software (version 22, SPSS Inc., Chicago, IL). The level of significance was set at .05 for two-sided hypothesis testing. For all variables frequency distributions were generated. Continuous variables (e.g., percent changes in weight, adherence to calorie and fat goals, age, education, BMI) were summarized at each time point in terms of central tendency and variability (mean and standard deviation, if normality assumption was met; median and inter-quartile range, if the assumption was not met), number of missing cases, minimum and maximum value, range, mode, and quartiles. The shape of the distribution was described via indices such as skewness and kurtosis. Characteristics of a

variable's distribution were depicted in graphical or tabular format, including histograms and stem-and-leaf plots, as appropriate. For nominally categorical variables (e.g., gender, race, employment) were summarized using the mode, range, and minimum and maximum and for ordinal categorical variables (e.g., income) were summarized using median and quantile range.

The data for each time point was screened (baseline and 6, 12, and 18 months). Outliers were graphically assessed by (1) looking at the histograms and checking the tails of distribution if there were data points falling away as extreme values; (2) inspecting boxplots; (3) using the extreme values table by examining the highest and the lowest values recorded; (4) generating and checking the absolute value of the data transformed Z-scores applying a cut-point of ± 3.29 corresponding to $p<.001$ from the standard normal (Z) distribution. If outliers were identified, we ascertained the validity of the value. Erroneous values were corrected. If correct, remedial measures (e.g., score alteration, data transformation) were applied as appropriate.

The underlying assumption for checking normality was performed. We used two ways of assessing normality. Histograms were used to graphically display the distributions of random variables or differences between an empirical distribution and a theoretical distribution (e.g., the standard normal distribution). Numerical methods presented summary statistics such as skewness and kurtosis, or conduct statistical tests of normality. We used the Kolmogorov-Smirnov test to check normality of data. The data transformations were applied to induce normality when data were non-normally distributed. Based on prior experience, non-normality of weight data was often due to the presence of outliers or extreme values. We transformed these outlying values using score alteration methods to yield values that were smaller than the extreme data and closer to the bulk of the data.

If missing data was detected, the amount and pattern of missing data was evaluated and appropriate strategies to handle the missing data were applied. For example, if data was missing completely at random or missing at random, a mixed effect modeling was able to accommodate the missingness. If data was not ignorable missing, multiple imputation methods were employed. For the missing data from Carematix scale, some scale data was missing a date-stamp due to technical issues and was imputed using retrieved dates. The weight data without dates was coded as missing.

Data Analysis Procedures

Data Analysis Plan for Aim 1. Linear mixed modeling (considering parameterization of the variance-covariance structure of the repeated measures) was used to examine the changes in mean days of self-weighing per week and the percentage of weeks adherent to the self-weighing protocol over time. We initially explored the variance-covariance structure of the repeated assessments and determined the variance-covariance structure that best fit the data using standard information criteria (e.g., AIC, BIC). Models included a fixed effect for time (specified as a categorical/class variable) and random effects for subject. Post-hoc comparisons were conducted between time points to determine the point where significant changes occurred. Following the fitting of models, assumptions (e.g., normality) were evaluated by checking residual distribution. Missing data were handled through the linear mixed modeling assuming missing at random by checking missing pattern. Sensitivity analyses were conducted for possibly influential cases identified as outliers through graphical methods. If outliers were omitted via sensitivity analyses and the conclusions did not change, this supported the robustness of our findings. We reported estimated regression coefficients with confidence intervals, values of test statistics, and p-values.

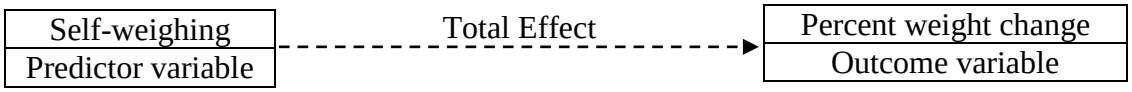
Data Analysis Plan for Aim 2. Linear mixed modeling was used to examine the association between electronically recorded self-weighing and weight change. We also initially explored the variance-covariance structure of the repeated assessments and determined the variance-covariance structure that best fit the data using information criteria (e.g., AIC, BIC). Models included a fixed effect for time (specified as a class variable) and random effects for subject and self-weighing (mean days of self-weighing per week or percentage of weeks adherent to the self-weighing protocol), the dependent variable for the model was percent weight change. We first checked the interaction between time and self-weighing. If there was a significant interaction effect on the outcome, this was the model that we applied; otherwise, we excluded the interaction effect and only examined the main effects of time and self-weighing on the outcome. We also checked the assumptions, conducted the sensitivity analyses and handled the missing data using the same method as described in the above paragraph. We reported estimated regression coefficients with confidence intervals, the values of test statistics, and p-values.

We also checked potential confounder variables individually, e.g., age, race, education, and gender, to examine if these variables were associated with self-weighing, adherence variables and percent weight change. If a specific potential confounder variable was associated with all the predictor, mediator and outcome variables, then we controlled for them.

Data Analysis Plan for Aim 3. For the examination of the mediating effects of adherence to calorie goals on the association between self-weighing and percent weight change, the first step was to examine the bivariate association among the variables of self-weighing, adherence and percent weight change. The approach was the same as described for aim 2. If there were significant bivariate associations, then we examined the mediation effect of adherence at each

time point. The predictor was mean days of self-weighing/proportion of weeks of adherence to self-weighing, the outcome was percent weight change, and the mediator included proportion of session adherence to calorie goal or exercise goal (Figure 1). For example, if we used adherence to calorie goal as a mediator, we first modeled the direct effect of self-weighing on percent weight change: (1) the effect of adherence to calorie goal on self-weighing; (2) the effect of adherence to calorie goal and self-weighing on percent weight change. Then we modeled the indirect effect, the model was: adherence to calorie goal and self-weighing on percent weight change. Next, we conducted the longitudinal mediation analysis.

A.



B.

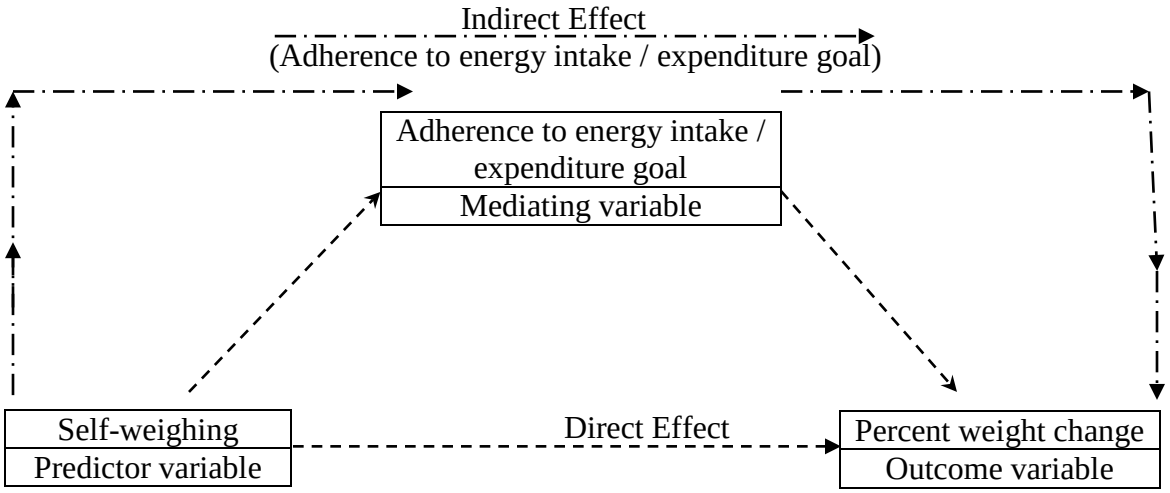


Figure 1. Total, Direct and Indirect Effects of Self-Weighing on Percent Weight Change

1.3.2 Qualitative Component

1.3.2.1 Study design

We conducted a qualitative study using focus group methodology to describe participants' perception and acceptance of daily weighing as well as their perceived benefits and barriers to adherence to daily weighing while being a participant in the EMPOWER study (L.E. Burke, R01HL107370).

1.3.2.2 Recruitment and sampling

We purposefully recruited the proposed study sample when participants completed the EMPOWER study (N=151). Eligibility criteria of the EMPOWER study were that individuals: (1) were ≥ 18 of age (2) had a BMI between 27 and 44, inclusive, and (3) had not participated in a weight loss program in the past 3 months. Individuals were excluded if they: (1) had the presence of any condition that may confound study findings (e.g., diabetes, pregnancy, post bariatric surgery); (2) planned to become pregnant in the next 12 months; (3) planned frequent travel, extended vacations or relocation in next 12 months; (4) were receiving current treatment for a serious mental illness; (5) reported alcohol intake ≥ 4 drinks/day; or (6) were unable or unwilling to use the smart phone for EMA data collection.

The sample (N=30) was comprised of participants that were representative of the parent study in terms of gender, ethnicity, and adherence to daily self-weighing. The EMPOWER sample was representative of the ethnic composition of Pittsburgh with approximately 30% minority enrollment (recruitment is ongoing). We recruited participants from cohorts 2 (n=15), 3 (n=32) and 4 (n=24) of the EMPOWER study. Because cohort 1 completed the study in May 2013, we did not recruit participants from this cohort. Cohort 2 completed the study in October 2013, which was prior to the proposed study; we conducted a preliminary focus group study using this cohort. Cohorts 3 and 4 completed the study in April and May 2014, respectively. We proposed to enroll a maximum of 30 participants from cohorts 2, 3 and 4 and conducted two focus groups (6-10 participants in each group). At the final group treatment session of the EMPOWER study, participants were told about the focus group study and asked if they wished to participate. If they wished to participate in the focus group, we gave them the Consent to

Participate Form.They signed it then or at the final assessment visit, if they wished to give it more consideration.

1.3.2.3 Data collection

We used a semi-structured interview format consisting of eight open-ended statements and questions (see Appendix1). Using open-ended statements encouraged participants to discuss their experience of daily weighing during the weight loss study. We conducted the focus group in a private room in the School of Nursing Clinical Research Center and used two recorders to audiotape the sessions; a student worker assistant took notes. We assured participants that we were interested solely in their perceptions of daily self-weighing and that there was no correct or incorrect response and absolutely no judgment of any response. Participants were encouraged to discuss what they believe about self-weighing and also what they felt/experienced when they weighed themselves during the 12-month study. Each focus group lasted approximately 50 minutes. We explored:

Acceptance and perception of daily weighing; a sample statement: P*lease tell me about your experience of daily weighing during the EMPOWER study.*

The role daily weighing played in achieving weight loss; sample questions: *How did the information about your weight influence the management of your food plans for the day, in particular the foods you selected to eat? Also, did the information about your weight influence your physical activity/exercise behaviors?*

Perceived benefits and barriers of adherence to daily weighing; sample questions: Did *you see benefits to weighing yourself daily? If so, what were the benefits? Were there barriers to weighing yourself daily? If so, what were they? How did they affect your daily weighing?*

Future suggestions; sample questions: *Would you recommend self-weighing on a regular basis to a family member or friend? Do you have any suggestions for how best to use daily weighing in future weight loss programs?*

1.3.2.4 Data Analysis

The student worker transcribed the recorded content and the PI performed an accuracy check, listening to the recording and comparing the transcript to the recording. Following this check, we conducted content analysis. The PI and the student worker read transcripts and field notes, identifying the main themes and subthemes. Initial codes were created and defined, followed by code development and refinement. At the same time, we met with an expert in weight loss treatment research and an expert in qualitative research methods weekly during data analysis and discussed the code development. Data analysis followed standard procedures for coding qualitative data (Field & Morse, 1991). ATLAS-Ti software (ATLAS-Ti, 5.0, Scientific Software, Berlin) was used to assist with coding, filing, organization and retrieval of data. We also examined the proposed sample's quantitative data, which were collected in the EMPOWER study, and categorized into different patterns of adherence to daily weighing. Following these procedures, we examined the qualitative data within each category of the quantitative data.

1.4 POTENTIAL LIMITATIONS OF THE PROPOSED PROCEDURES & ALTERNATIVE APPROACHES

One of the main limitations inherent to secondary analyses was the potential incongruence between the primary and secondary research objectives and the quality of the data collected by

the parent study (Babbie, 2008; Bibb, 2007). Having worked on the parent study and previewed the dataset, we knew that the variables and data collected in the parent study matched the secondary research objectives (Bibb, 2007). Another potential limitation was that, in the SELF study, the self-weighing data contained missing values due to technical problems, which was not the usual type of missing data. The solution for this type of missing data was that the data could have be imputed using retrieved data. Fortunately, the self-weighing data from the EMPOWER study had minimal missing data. The results from the SELF study on adherence to self-weighing and its association with percent weight change could have be validated by those from the EMPOWER study.

The second potential challenge was recruitment for the qualitative study. There was always the potential for not being able to recruit sufficient participants from cohorts 2, 3 and 4 of the EMPOWER study; however, should this have occurred, we could have recruited participants from waves 5 and 6, however, this would have required additional time to complete the qualitative component of the study. Fortunately, we were were able to recruit the required number of participants from the cohorts 2, 3 and 4.

1.5 RESEARCH PARTICIPANT RISK AND PROTECTION

All interaction with human subjects took place at the University of Pittsburgh site. We conducted a secondary analysis using quantitative method. For the qualitative component, we invited 30 adults who completed the EMPOWER study to participate in the focus group study. The proposed sample included a sample that was representative of the parent study in terms of gender, ethnicity, and adherence to daily self-weighing. The parent study completed recruitment

in January 2014 with an enrollment of six cohorts (N=151). The sample was comprised of 88.7% females, 19.2% minority populations as well as a mean age of 51.2 years old and a mean BMI of 34.0 kg/m^2. This research study did not involve special classes of subjects such as fetuses, neonates, pregnant women, children (under age 18), prisoners, institutionalized individuals, or populations considered vulnerable.

Approval by the Institutional Review Board was obtained prior to the initiation of the study and an informed consent was obtained from all participants prior to their participation in a focus group. There were no risks associated with participating in the proposed study. Maintaining confidentiality of the information was a very important concern. We followed several rules. First, confidentiality of information was maintained and assured by use of a unique numerical code that was used for managing data. Second, a master list of participant names and code numbers were kept in a locked file cabinet separate from the data and maintained by the PI. The PI monitored data management and security. Third, file of transcribed data from the focus groups were identified by study ID number only. Fourth, every precaution was taken to minimize exposure of the data to persons outside of this project by using passwords for all computer files and keeping all hard copies of data within locked files within the research project area. Last, the taped interview content on the recorder was saved on secure server.

The participants received no direct benefits from taking part in the proposed research study, but they learned more about the role of daily weighing and how it might benefit them in the future management of their weight. The results of the study could help us understand the acceptance of daily weighing and the perceived benefits and barriers of adherence to daily weighing, which would inform the development of an intervention to enhance adherence to this important behavior change strategy. Participants were compensated $10-25 for their time and for

participating in the focus group and $5 for parking or transportation. Food and drinks were available at the focus group sessions.

Internal Review Board (IRB) status was expedited since the proposed study involves no risks associated with participating in the study. IRB approval was obtained for the focus group study.

2.0 MANUSCRIPT 1: ASSOCIATION BETWEEN SELF-WEIGHING AND PERCENT WEIGHT CHANGE: MEDIATION EFFECTS OF ADHERENCE TO ENERGY INTAKE AND EXPENDITURE GOALS

2.1 ABSTRACT

Background: To date, no research has examined electronically recorded self-weighing behavior beyond nine months or the underlying mechanisms of how self-weighing may impact weight change. **Objectives**: 1) Examine electronically recorded self-weighing behavior in a weight-loss study; 2) examine the possible mediating effects of adherence to energy intake (EI) and energy expenditure (EE) goals on the association between self-weighing and weight change. **Design**: This was a secondary analysis of the self-efficacy enhancement (SE) arm of an 18-month randomized clinical trial. **Participants/setting:** The study was conducted at the University of Pittsburgh (2008-2013). Overweight or obese adults with at least one additional cardiovascular risk factor were eligible. **Intervention**: Participants in the SE arm were provided a scale (Carematix, Inc.) and instructed to weigh at least 3 days/week or every other day. The scale date- and time-stamped each weighing episode, storing up to 100 readings. **Main outcome measures**: Weight was assessed every six months. Adherence to EI and EE goals were calculated on a weekly basis using paper diary data. **Statistical analyses performed**: Linear mixed modeling and mediation analyses. **Results:** The sample (N=55) was 80% female, 69% Non-Hispanic

White, with mean (SD) age of 55.0 (9.6) years old and a BMI of 33.1 (3.7) kg/m^2. Percent weeks of adherence to self-weighing declined over time ($p<0.001$). From baseline to 6 months, there was a significant mediation effect of adherence to EI and EE goals on the association between adherence to self-weighing and percent weight change (indirect effect: b=-0.26, p=0.02; b=-0.23, p=0.02, respectively). However, the mediation effects were non-significant during the second and third 6-month periods of the study. **Conclusions:** The objectively measured adherence to self-weighing declined over 18 months. During the first six months, self-weighing directly impacted weight change and indirectly impacted weight change through changes in EI and EE.

2.2 INTRODUCTION

Self-monitoring of body weight has been recommended as a component of standard behavioral treatment (SBT) for weight loss (Cooper & Fairburn, 2001), a strategy also recommended by the Clinical Guidelines for Treatment of Overweight and Obesity of the National Heart, Lung, and Blood Institute (National Institute of Health. National Heart Lung and Blood Institute, 1998). Recent studies have demonstrated that frequent self-weighing is associated with greater weight loss (Gokee-Larose et al., 2009; Lally et al., 2008; VanWormer, Martinez, Martinson, et al., 2009; Welsh et al., 2009; Yaguang Zheng et al., 2013), less weight regain (Sherwood et al., 2013; R. R. Wing et al., 2006) and better weight gain prevention (French et al., 2011; Gokee LaRose et al., 2010; VanWormer et al., 2012).

A weakness of the reported studies was the method used to assess self-weighing. Most of the studies used self-report methods and queried the participants retrospectively about the frequency of self-weighing (e.g., daily, weekly). For example, some studies used a single

question asking about frequency of self-weighing with response options being *never, about once a year or less, every other month, once a month, once a week, once a day, or more than once a day* (French et al., 2011; Gokee LaRose et al., 2010; Jeffery & French, 1999; Kong et al., 2012; Linde & Jeffery, 2011; Sherwood et al., 2013; Sherwood et al., 2006; VanWormer et al., 2012; Welsh et al., 2009). However, these self-report methods might not accurately reflect the actual weighing behavior because self-reporting tends to over-report (Daniels et al., 2011; Ross-Degnan et al., 2010) or recall bias (Stone et al., 2000) of self-weighing frequency. Thus, more objective measures of self-weighing frequency are needed to validate the association of a self-weighing intervention strategy with weight loss.

To the best of our knowledge, only three of the recent studies have used electronic scales to objectively measure self-weighing behaviors (Gokee-Larose et al., 2009; Steinberg et al., 2013; VanWormer, Martinez, Martinson, et al., 2009). Vanwormer and colleagues used a telemonitoring scale (Thin-Link, Cardiocom, LLC., Chanhassen, MN) that transmitted weight data automatically to the research center through a telephone land line (VanWormer, Martinez, Martinson, et al., 2009). Gokee-LaRose reported using a scale that stored weight data for 31 days (Gokee-Larose et al., 2009). Steinberg et al. used a smart scale that displayed current weight and transmitted the data directly to a website (www.bodytrace.com) via a wireless cellular network (Steinberg et al., 2013). The limitations of these studies included small and homogeneous samples and short-term follow-up (e.g. 6 months), limiting the generalizability of the findings.

Additionally, a few studies reported adherence to self-weighing over a short period of time, e.g., six months. Gokee-Larose et al. reported that at the end of a 10-week intervention approximately 90% of the participants weighed themselves daily, a rate that decreased significantly at the 20-week follow-up (Gokee-Larose et al., 2009). This pattern of initial high

level of adherence to self-weighing followed by a gradual decrease after approximately 3 months has also been reported by others (Linde & Jeffery, 2011; Steinberg et al., 2013). Further, data provide evidence for a gradual decline in adherence to self-monitoring of diet and exercise, which becomes worse when treatment sessions and interventionist contact decrease (Burke, Wang, et al., 2011). Although research related to self-monitoring of diet and exercise is extensive, it remains unclear whether the pattern of adherence to self-weighing, a component of self-monitoring, is similar to or differs from that of long-term self-monitoring of diet and exercise.

Moreover, no study has reported the underlying mechanisms of how self-weighing impacts weight change. Mediation analysis can determine the impact of each link in a hypothetical chain of events and define the contribution of different program components, which provides an explicit check on an intervention's theoretical underpinnings and whether the proposed change process was achieved (Lockwood, DeFrancesco, Elliot, Beresford, & Toobert, 2010). Exploring these mechanisms will provide data to inform interventions to better counsel participants on the use of self-weighing for weight management.

According to self-regulation theory, motivation for behavioral change results from the interplay among self-observation, recording, awareness, and self-evaluation (F. Kanfer & Goldstein, 1990). Regular self-weighing may increase individuals' awareness of eating and exercise behaviors, which may result in changes in balance of energy intake and expenditure, which may impact weight loss (Butryn et al., 2007). Therefore, we conducted mediation analysis to examine if self-weighing impacted weight loss through changes in eating and exercise behaviors.

The aims of our study were to 1) examine electronically recorded self-weighing behavior in a long-term weight loss study; and 2) examine the mediating effects of adherence to energy intake / expenditure goals on the association between self-weighing and percent weight change. By conducting mediation analysis, we will explore the underlying mechanism of how self-weighing impacts weight change.

2.3 METHODS

2.3.1 Study design

This was a secondary analysis of data (N=58) from the self-efficacy enhancement (SBT+SE) arm of the SELF trial. Since only the participants in SBT+SE group were provided an electronic scale to weigh themselves at home, we used only the data from the SBT+SE arm for data analysis. The parent study was a 2-group, single-center, 18-month clinical trial of a behavioral weight-loss intervention for obese/overweight adults (Figure 2) (Burke, Styn, Ye, Sereika, & Ewing, 2012). The study was conducted at the University of Pittsburgh (2008-2013). The primary outcome of the parent study was weight loss maintenance. Both groups received a standard behavior treatment (SBT) intervention to promote weight loss (L.E. Burke et al., 2006). SBT is comprised of group-based cognitive-behavioral intervention strategies, daily dietary and weekly physical activity goals, and self-monitoring of daily energy and fat intake and physical activity. In addition to the group sessions, participants in the SBT+SE group met in person with their interventionist on a one-to-one basis. In these sessions, the interventionist implemented self-efficacy based strategies and worked with the participant to develop joint tailored, incremental

goals for diet and physical activity to facilitate weight loss. During the first 12 months, the one-to-one sessions were held every two weeks; thereafter, sessions were held at least monthly. Telephone sessions were available in place of face-to-face sessions at the participants' request. Individuals in the SBT+SE group were also provided with a scale (Carematix, Inc., Chicago, IL) to weigh themselves at home at least three times per week or every other day. The University of Pittsburgh Institutional Review Board approved the study protocol and all participants provided written informed consent.

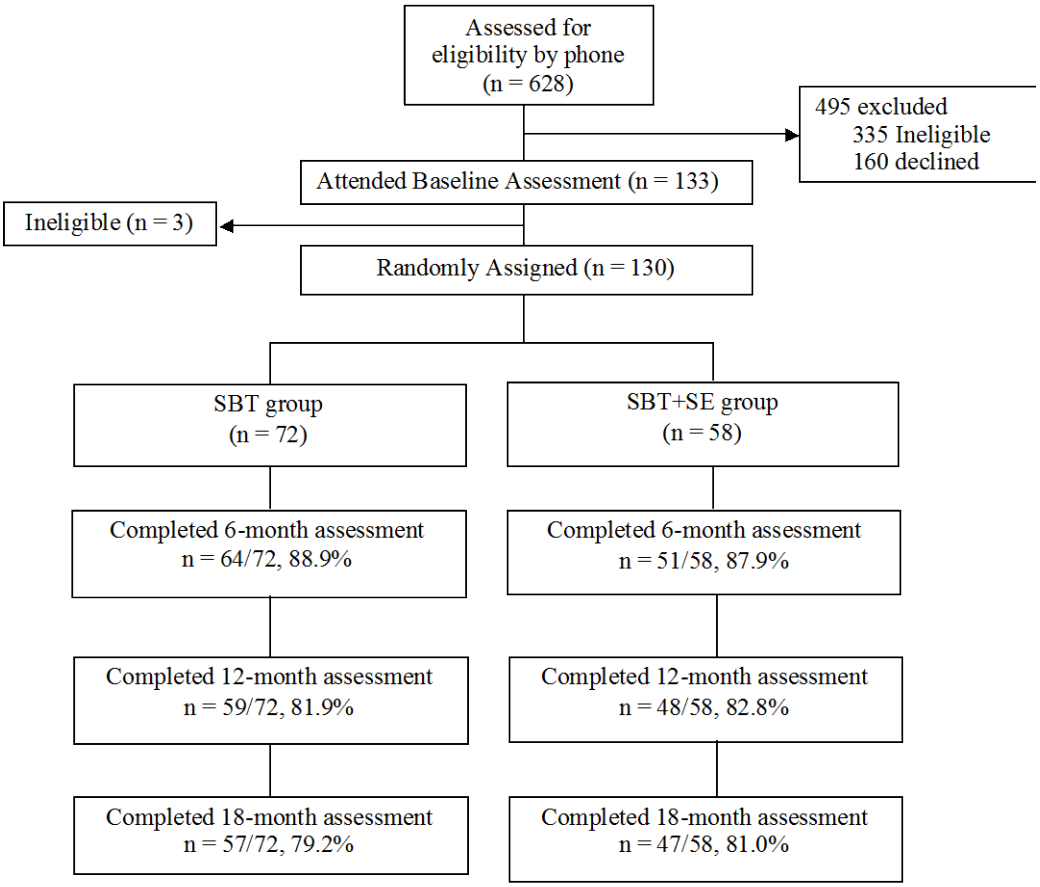


Figure 2. Assessment and Assignment of Participants in a Randomized Weight-Loss Intervention Trial

2.3.2 Sample

Overweight or obese adults with at least one additional risk factor for cardiovascular disease, e.g., dyslipidemia, hypertension, cigarette smoking, were eligible. During screening for eligibility, participants were asked to reasonably assess whether or not they would be able to commit to an 18-month intervention. They were excluded if they were planning a pregnancy or relocation that would prevent them from attending the group sessions. To minimize attrition, individuals who participated in weight loss treatment within the last 6 months were not eligible. Assessments were conducted every six months throughout the study as described below.

2.3.3 Measures

Socio-demographic Questionnaire. The Socio-demographic and Lifestyle Questionnaire, a self-administered, standardized questionnaire developed by the Center for Chronic Disorders at the University of Pittsburgh, was used to assess sociodemographic factors at baseline.

Weight. A digital scale (Tanita Corporation of America, Inc., Arlington Heights, IL, USA) was used to measure weight in pounds at baseline, 6, 12, and 18 months. Participants wore light clothing, no shoes, and had fasted overnight. Weight was transformed into percent change relative to baseline levels (t=0). That is, percent weight change was defined as ([weight$_t$ – weight$_0$] / weight$_0$) x 100%, t = 6, 12, 18 months.

Self-weighing. Each self-weighing episode at home was date- and time-stamped using the scale provided, which stored a maximum of 100 readings that were uploaded every 3 months to a server in the research center. If data could not be transmitted from the scale to the server in our research center, the scale was returned to the manufacturing company for retrieval of the

weight data. Some of the retrieved data remained incomplete as a result of: 1) missing date-stamps due to technical issues and 2) missing both date-stamps and weights.

The outcome variables for analysis were calculated in two ways over three six-month blocks of time: 1) frequency of self-weighing was defined as the mean number of days of self-weighing per week; 2) percent time adherent: (number of weeks adherent to self-weighing / total number of weeks in each 6-month block) x 100%, where adherence for each week was defined as self-weighing ≥3 days / week.

Adherence to energy intake (EI) goal. Adherence to energy intake goals was calculated on a weekly basis using the data from the paper diary recording of dietary intake. Adherence to the EI goal was calculated by dividing the total number of calories consumed per week by the weekly calorie goal, then multiplying by 100 to express the value as a percentage, e. g, if a participant with a daily calorie goal of 1800 Kilocalories (Kcal) [weekly goal = 12,600] reported consuming 10,500 total Kcal in a week, the level of adherence to the energy goal was calculated as 83.3% (10,500/12,600 × 100%) (Acharya et al., 2009). Adherence to the EI goal was categorized as adherent (reported consuming 85%–115% of the weekly goals) and non-adherent (reported consuming <85% or >115% of the weekly goals) on a weekly basis. If a diary was not returned, adherence to EI goals was coded as non-adherent for that week. For the analysis, we calculated the proportion of sessions the participant was adherent to the EI goal, dividing the number of sessions adherent to the calorie goal by the total number of sessions in each six-month period.

Adherence to energy expenditure (EE) goal. Adherence to energy expenditure goal was calculated on a weekly basis using the data from the paper diary recording of exercise minutes. Adherence was calculated using the reported weekly minutes spent exercising divided

by the weekly goal. For example, for a person who reported 140 minutes of exercise when the goal was 150 minutes a week, adherence to the goal was 93% (140/150 × 100%). Since the exercise goal was increased over the first six weeks, the denominator was changed accordingly. Adherence to the EE goal was examined as a binary variable based on whether participants achieved the goal each time their diaries was submitted (adherent: ≥100% of weekly goal, nonadherent: <100% of weekly goal). For the data analysis, we calculated the proportion of sessions the participant was adherent to the EE goal in each six-month period.

2.3.4 Statistical Analysis

Statistical analyses were conducted using SAS version 9.3 (SAS Institute, Cary, NC. 2012) and Mplus (version 7.31, Muthén & Muthén, Los Angeles, CA, 2012) for Windows. Significance was set at .05 for two-sided hypothesis testing. Summary statistics were reported as mean (SD) and frequency count (%). The normality of variables was tested using Shapiro-Wilk and histograms were also reviewed.

Linear mixed modeling was used to examine the longitudinal association between self-weighing and weight change over 18 months. The scale data that were missing a date-stamp due to transmission issues were imputed using data retrieved by the company while the scale data that were missing dates and weights were coded as missing. The missing values were handled by a linear mixed model. Sensitivity analyses were conducted. The conclusions did not change when the missing data were handled as either missing or zero. Also, the conclusions did not change when the analysis was conducted using the smaller sample with complete data. The results from sensitivity analyses supported the robustness of our findings.

Next, the mediation analyses were conducted. Mediation is the extent to which a mediator variable, M, is intermediate in a relationship between an independent variable X and dependent variable Y (Lockhart, MacKinnon, & Ohlrich, 2011). Mediation analysis helps researchers modify, improve, and develop more cost-effective interventions by identifying and refining their critical components (Lockwood et al., 2010). Three main effects are involved for a mediation analysis: 1) total effect: establish an overall effect between X and Y; 2) direct effect: establish an effect between X and Y after controlling for M; 3) indirect effect: establish an effect of X on M and M on Y after controlling for X (Lockwood et al., 2010). Researchers often test whether there is complete or partial mediation by testing whether the indirect effect is statistically significant, which is a test of whether the association between the independent and dependent variable is completely accounted for by the mediator. If the total and indirect effects are significant and the direct effect is not significant, then there is evidence for complete mediation. If all three effects are significant, then there is evidence for partial mediation (MacKinnon, Fairchild, & Fritz, 2007).

When conducting the mediation analysis for this study, the predictor was adherence to self-weighing, outcome was percent weight change, and the mediator considered was the percentage of time participants were adherent to EI goal or EE goal. The simple mediation effect for each 6-month period was examined individually for adherence to the EI or EE goals. Next, both adherence to EI and EE goals were added into the model simultaneously to examine the effects of multiple mediators. For each mediation analysis, we estimated the total, direct and indirect effects. For example, when adherence to EI goal as the mediator was examined, total effect: percent weight change = adherence self-weighing; direct effect: percent weight change = adherence self-weighing after adjusting adherence EI; indirect effect: (percent weight change =

adherence EI) x (adherence EI=adherence self-weighing). We conducted bootstrapping with 5000 bootstraps since the distributions of adherence to self-weighing and adherence to EI and EE goals were not normal. The fit indices including RMSEA (≤.06), SRMR (≤.08), and CFI (≥.95) were checked to examine the model fit (Hu & Bentler, 1999).

2.4 RESULTS

The total sample was 55 participants for analysis since data for three participants were excluded due to medical issues (e.g., new diagnoses of type 2 diabetes or cancer) or participant did not use the scale. The sample was 80% female, 69% Non-Hispanic White, 64% married or cohabiting, 67% household income >$50,000, on average (SD) 55.0 (9.6) years of age, had a mean 15.9 (2.6) years of education, and a mean BMI of 33.1 (3.7) kg/m^2 at entry. A total of 17 (31.0%) participants had complete data for self-weighing. Of the available 7550 self-weighing records, 15.3% were imputed using retrieved dates.

The mean number of days of self-weighing per week varied over time and was 2.2 (1.1) during the first 6 months, and declined to 1.8 (1.1) over the second 6-month period and to 1.5 (1.2) in the third or final 6-month period ($F = 12.14$, $p<0.001$). Percent time of adherence to self-weighing declined from 44.1% to 36.9% to 29.3% over the first, second and third 6-month periods ($F=23.23$, $p<.001$), respectively. The percentage of the sample adherent to self-weighing declined over 18 months (see Figure 3). The percent weight change relative to baseline was -7.3%, -8.4%, and -8.0% at 6, 12 and 18 months ($F=5.98$, $p=0.005$), respectively.

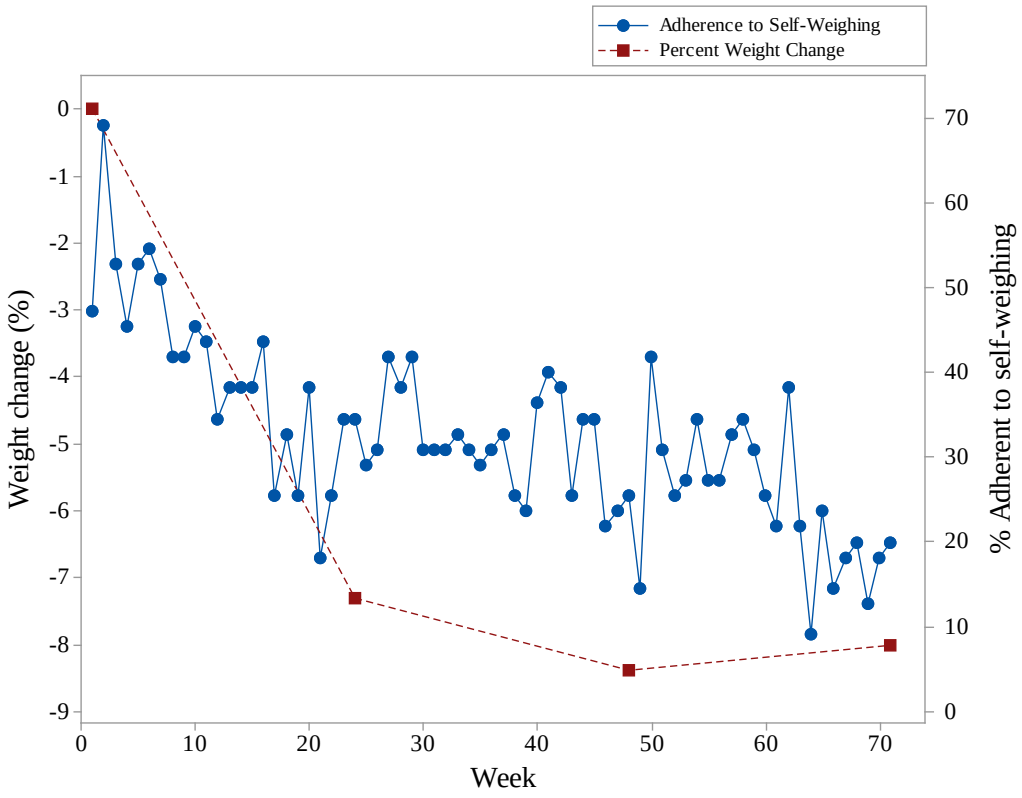


Figure 3. Percentage of Sample Adherent to Self-Weighing and Mean Percent Weight Change over Time

Percentage of time that participants were adherent to self-weighing was linearly associated with percent weight change over 18 months (b=-0.032, p=0.047), indicating that an increase in one week of adherence to self-weighing resulted in 0.03% of weight loss over 18 months. For the mediation effect, from baseline to 6 months, there was an association between adherence to self-weighing and percent weight change (total effect, b=-0.53, p<0.001), indicating that an increase in one week of adherence to self-weighing resulted in 0.53% of weight loss during the first 6 months of study. When examining adherence to EI goal as a mediator (Figure 4), there was a significant direct (b=-0.36, p=0.03) and indirect (b=-0.26, p=0.02) effect of self-weighing on percent weight change. Similarly, when examining adherence to EE goal as a mediator (Figure 5), there was also a significant direct (b=-0.31, p=0.001) and indirect (b=-0.23,

p=0.02) effect of self-weighing on percent weight change. These results indicate that both adherence to EI and EE goals had a partial mediation effect on the association between adherence to self-weighing and weight change for the first 6 months since the total, direct and indirect effects were all significant. All the model fit indices for each model, indicated that the models fit well.

However, for the second and third 6-month periods, no significant mediation effect for adherence to EI goal was found since the indirect effects were not significant for the second 6-month period (indirect effect: b=0.12, p=0.19) and the third 6-month period (indirect effect: b=-0.005, p=0.52). On the other hand, there was a significant mediation effect for adherence to EE goal had during the second 6 months (indirect effect: b=-0.03, p=0.01), while there was no significant mediation effect for adherence to EE goal during the third 6 months (indirect effect: b=-0.02, p=0.09). Also, when adherence to EI and EE goals were added into the model simultaneously, no significant mediation effects were observed for each 6-month interval.

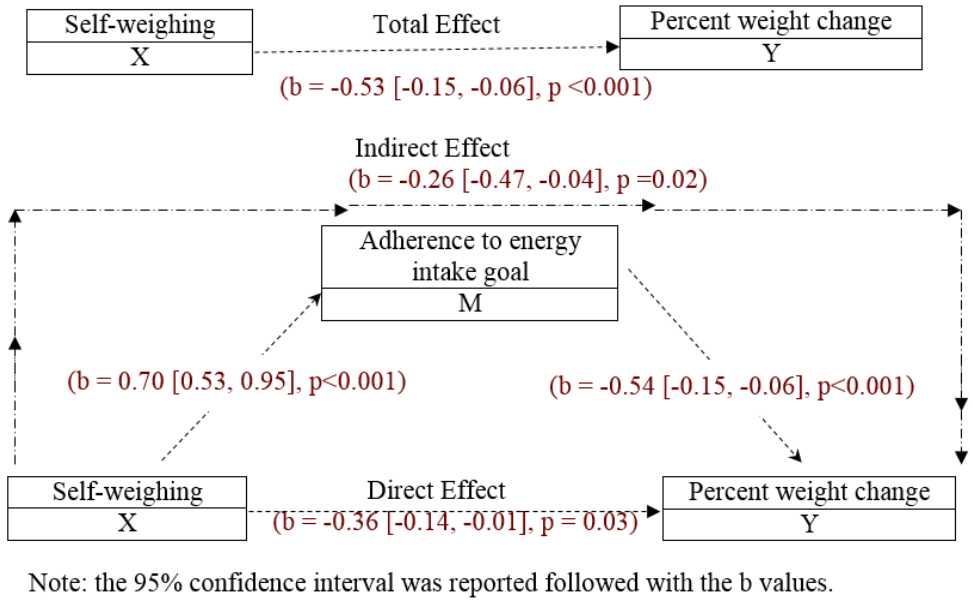


Figure 4. Mediation Effect of Adherence to Energy Intake Goal from 0 to 6 months

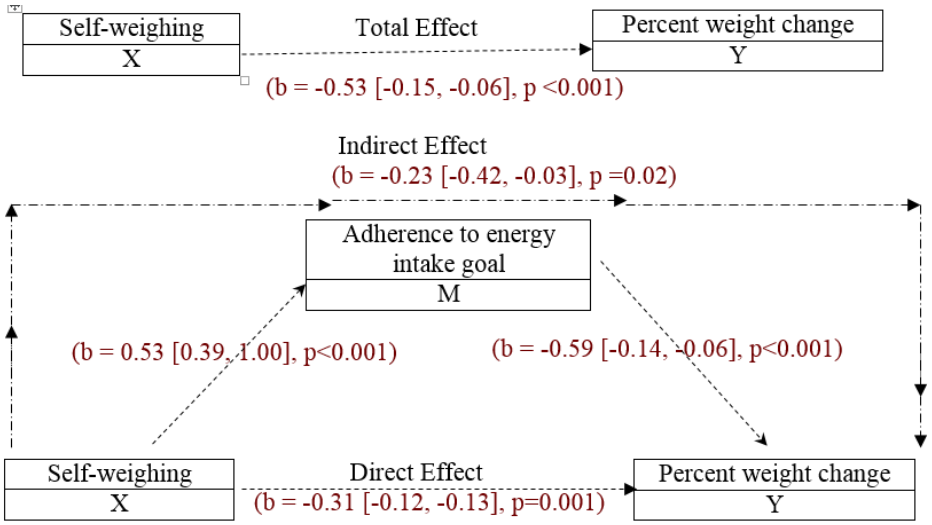


Figure 5. Mediation Effect of Adherent to Energy Expenditure Goal from 0 to 6 months

2.5 DISCUSSION

This is the first study to look at the mediation effects of using the longitudinal objectively assessed self-weighing data. The use of date-stamped data from an electronic scale revealed that adherence to self-weighing declined throughout the 18-month follow-up. Both adherence to EI and EE goals showed partial mediation effects on the association between adherence to self-weighing and weight change during the first 6 months of the follow-up.

Data from our study, in which participants used an electronic scale that documented the weighing events, confirmed that self-weighing was significantly associated with weight loss. Adherence to self-weighing was assessed using the date-stamped weight data. The data also

demonstrated a decline in adherence to self-weighing over the 18-month weight loss study, a pattern that is consistent with self-weighing adherence even over shorter periods (e.g., six months) (Gokee LaRose et al., 2010; Gokee-Larose et al., 2009; Linde & Jeffery, 2011; Steinberg et al., 2013). Moreover, data from this investigation replicated the pattern of declining adherence over time that has been observed for numerous other lifestyle behaviors, e.g., self-monitoring of diet, changing one's eating habits (Acharya et al., 2009) (Burke, Wang, et al., 2011), and exercise programs (Goodpaster et al., 2010). This growing body of evidence demonstrating a decline in adherence across numerous behavioral domains heighlights the need for the development of new strategies that can enhance and sustain adherence to treatment protocols that target weight loss.

Our mediation results showed that adherence to both EI and EE goals had partial mediation effects on the association between adherence to self-weighing and weight change during the first 6-month period, indicating that self-weighing not only directly impacts weight change but also indirectly impacts weight outcome through changes in dietary intake and exercise behaviors. The association between adherence to self-weighing and weight change reduced from -0.53 to -0.36 after adjusting adherence to EI goal during 0-6 months, while this association was reduced from -0.53 to -0.31 after adjusting adherence to EE goal. By observing the scale readings, participants may observe small weight changes and relate this to current diet or exercise behaviors, which in turn can support improved self-regulation of related behaviors. Realization of how body weight fluctuates may allow individuals to focus on their behaviors rather than weight outcomes. Our results did not demonstrate significant mediation effects of adherence to EI and EE goals during the second and third 6-month periods of follow-up, which

may be explained by the declining adherence and thus the increasing amount of missing data that reduced the variability for each behavior variable.

The definition of adherence to prescribed self-weighing protocols varies across reported studies. VanWormer et al. defined adherence to self-weighing as the percentage of days self-weighing occurred (i.e., total number of days self-weighed divided by the total number of days in the active treatment phase) (VanWormer, Martinez, Martinson, et al., 2009). Gokee-Larose et al. reported the proportion of participants who, at the end of the 10-week intervention and the 20-week follow-up, had adhered to weighing themselves daily (Gokee-Larose et al., 2009). Other investigators have simply reported mean days per week of self-weighing (Steinberg et al., 2014). The inconsistent definition of adherence used across studies underscores the need for established measures and a consistent definition of adherence to self-weighing so that adherence can be compared across studies and different patient populations.

In our study, some self-weighing data were incomplete due to technical issues, e.g., data not transmitted via the modem. Advances in technology permit real-time transmission of self-weighing data, limiting data loss. Thus, the use of currently available technology-supported scales that provide date- and time-stamped measures of self-weighing may facilitate future studies of adherence to self-weighing and its association with weight change.

The main limitation of this study is missing data due to technical issues encountered with the scale that was available at the onset of our study. Also, the generalizability of these findings may be limited due to the predominantly non-Hispanic-White female sample. Additional limitation is the use of paper-and-pencil diaries rather than use of mobile technology to collect diet data in real time and thus avoid recall of food intake and the lack of use of wearable sensors to collect objective measures of energy expenditure to examine adherence to exercise. A major

strength of the study was the use of a scale equipped with a date-stamp to document self-weighing episodes and adherence during an 18-month weight loss intervention study. This is also the first paper to explore the underlying mechanism of how self-weighing impacts weight change. Exploring the role of mediators provides data to inform interventions to better counsel participants on the use self-weighing for weight management.

In conclusion, the data from the electronic scales in this study demonstrated that adherence to self-weighing over 18 months was significantly associated with weight change. This was the first study to use an electronic scale that stored data with a date stamp, permitting us to document adherence to self-weighing. The study was also the first one to examine the underlying mechanism of the impact of self-weighing on weight change and therefore adds to the literature supporting the use of electronic self-weighing as a strategy to enhance weight loss. The findings from the mediation analysis provide evidence for researchers to address the self-weighing strategy in future weight loss interventions as a means to enhance individual's ability to self-regulate food intake and the level of physical activity.

3.0 MANUSCRIPT 2: PATTERNS OF SELF-WEIGHING BEHAVIOR AND WEIGHT CHANGE IN A WEIGHT LOSS STUDY

3.1 ABSTRACT

Background: Regular self-weighing has been associated with weight loss and maintenance in adults enrolled in a behavioral weight loss intervention; however, few studies have examined patterns of adherence to a self-weighing protocol. The study aims were to 1) identify patterns of self-weighing behavior; and 2) examine adherence to energy intake and step goals and weight change by self-weighing patterns.

Method: This was a secondary analysis of self-monitoring and assessment weight data from a 12-month behavioral weight loss intervention study. Each participant was given a scale that was Wi-Fi-enabled and transmitted the date-stamped weight data to a central server. Group-based trajectory modeling was used to identify distinct classes of trajectories based on the number of days participants self-weighed.

Results: The sample (N=148) was 90.5% female, 81.1% Non-Hispanic White, with a mean (SD) age of 51.3 (10.1) years, had completed an average of16.4 (2.8) years of education and had mean BMI of 34.1 (4.6) kg/m^2. Three patterns of self-weighing were identified: *high/consistent* (75.0% self-weighed over 6 days/week regularly); *moderate/declined* (16.2% declined from 4-5 to 2 days/week); *minimal/declined* (8.8% declined from 5-6 to 0 days/week). The *high/consistent*

group achieved greater weight loss than the other two groups at 6 months (10.19%, 5.45%, and 2.00%) and 12 months (9.90%, 5.62%, and 0.65%), respectively.

Conclusions: This is the first study to reveal distinct temporal patterns of self-weighing behavior. The majority of participants were able to sustain a habit of daily self-weighing with regular self-weighing leading to weight loss and maintenance.

3.2 INTRODUCTION

Self-monitoring of body weight has been recommended as a component of standard behavioral treatment (SBT) for weight loss (Cooper & Fairburn, 2001; National Institute of Health. National Heart Lung and Blood Institute, 1998). Frequent self-weighing might improve individuals' awareness of their eating and exercise behaviors, provide early detection of subtle weight increases and prevent weight regain after weight loss (R. R. Wing et al., 2006). In recent years, the number of research articles on this topic has increased, which reflects the growing interest in self-weighing as a treatment strategy for weight loss (Harrison, Teede, & Lombard, 2014; Madigan, Jolly, Lewis, Aveyard, & Daley, 2014; C. R. Pacanowski & Levitsky, 2015; R. R. Wing et al., 2015). A recent systematic literature review reported that regular self-weighing is associated with successful weight loss, weight maintenance, and weight gain prevention in adults seeking behavioral weight loss treatment (Y. Zheng et al., 2015). Another recent literature review also reported that daily self-weighing may be a useful strategy for certain adults to prevent weight gain, lose weight, or prevent weight regain after loss (Carly R. Pacanowski, Bertz, & Levitsky, 2014). There were ongoing studies that continue to provide supportive evidence for daily weighing leading to better outcomes (Linde et al., 2015; Madigan et al., 2015).

Technology now permits recording and transmitting weight data in real time. Steinberg et al. conducted a behavioral weight loss study focusing on daily weighing. They used a smart scale that displayed current weight and sent the data directly to a website (www.bodytrace.com) via the wireless cellular network (Steinberg et al., 2013). The results demonstrated that the intervention group self-weighed on average (SD) 6.1±1.1 days per week during the initial 6 months; however, this declined to 4.0±2.3 days per week, on average, during the subsequent three months. In our previous 18-month behavioral intervention for weight loss trial, we used a scale that stored the data and demonstrated that the mean number days of self-weighing per week significantly declined from 2.48 days per week during the first 6 months to 1.8 days per week during the second 6 months and to 1.5 in the final 6-month period (Y. Zheng, Sereika, Danford, Ewing, & Burke, 2015. (Under 1st review)).

Results of self-weighing interventions are limited by investigators reporting those behaviors over time for the entire sample; this strategy ignores whether there are the subsamples of individuals with distinct patterns of self-weighing, e.g., consistent versus irregular self-weighing. Documenting the patterns of self-weighing notations in real time could provide information on how these patterns affect weight loss and if interventions can be developed to address deficits in self-weighing behaviors. However, no study has reported long-term distinct patterns of self-weighing. To address this gap, the aims of this investigation were to: (1) identify the patterns of self-weighing in a sample of adults undergoing SBT for weight loss; (2) examine the differences in adherence to lifestyle behaviors and percent weight change by self-weighing patterns.

3.3 METHODS

3.3.1 Study design

This was a secondary analysis of self-weighing data that were collected using Wi-Fi-enabled scales in the EMPOWER (LE Burke, R01HL107370) study. EMPOWER was a recently completed 12-month study of a behavioral intervention for weight loss in overweight and obese adults. All the participants received a standard behavioral intervention for weight loss that included group sessions, self-monitoring of dietary intake and exercise behaviors and provision of daily dietary and weekly exercise goals. The participants were encouraged to attend a total of 24 group treatment sessions that were held across the 12-month study. Participants were instructed to self-monitor their calorie and fat gram intake and minutes of physical activity using a self-monitoring application (Lose It!, FitNow, Inc., Boston, MA) on their smartphone or computer. The self-monitoring data were transmitted to the research server every night permitting a 24-hour lag time in the event the participant did not complete the daily self-monitoring that evening. The interventionist had access to the self-monitoring data in real time through a study-specific portal and thus accessed the participant's self-monitoring data and provided feedback via an email message at the same frequency as the intervention sessions, weekly for three months followed by bi-weekly for three months, then monthly for six months. Participants were also provided with the Withings Wi-Fi scale (Withings, Inc., Issy-les-Moulineaux, France) with instructions to weigh themselves at home daily soon after they arose from bed in the morning or at the same time every day. The scale date-stamped each weighing episode and transmitted the weight data to the LoseIt! server and to the project server in real time; participants also were able to see their weight data on their smartphone.

Participants. For the EMPOWER study individuals had to meet the following criteria: (1) be ≥ 18 years of age, (2) have a body mass index (BMI) between 27 and 44 m/kg^2, inclusive, and (3) not have participated in another weight loss program in the past 3 months. Individuals were excluded if they: (1) had the presence of any condition that may confound study findings (e.g., diabetes, pregnancy, post bariatric surgery); (2) planned to become pregnant in next 12 months; (3) planned frequent travel, extended vacations or relocation in next 12 months; (4) were receiving current treatment for a serious mental illness (e.g., schizophrenia); (5) reported alcohol intake ≥ 4 drinks/day; or (6) were unable or unwilling to use the smartphone.

3.3.2 Measures

Socio-demographic data. These data were collected using the self-administered Socio-demographic and Lifestyle Questionnaire. The questionnaire consists of 25 primary questions that were designed to assess standard socio-demographic and socioeconomic information including age, gender, marital status, education, employment status, income, and ethnicity/racial background.

Weight. Outcome weight was measured at baseline, 6, 12, and 18 months by a digital scale (Tanita Corporation of America, Inc., Arlington Heights, IL, USA) The assessment was performed following an overnight fast with participants wearing light clothing and no shoes. Weight data were transformed into percent change relative to baseline levels (t=0). That is, percent weight change was defined as ([weight$_t$ – weight$_0$] / weight$_0$) x 100%, t = 6, 12, 18 months.

Self-weighing. Self-weighing data were transmitted from the Wi-Fi-enabled scale to the research server. Based on the date-stamped information, we defined each day as binary (weighing vs. no weighing). We then calculated number of days of self-weighing for each week.

Adherence variables. The data on energy intake were obtained from the daily dietary recordings from LoseIt!. Adherence to the energy goal was calculated by dividing the total number of calories consumed on a specific day by the daily calorie goal, then multiplied by 100 to express the value as a percentage. For example, if a participant with a daily calorie goal of 1800 reported consuming 1500 total calories in a day, the level of adherence to the energy goal was calculated as 83.3% (1500/1800 × 100%). Based on the calculation of adherence to the energy intake goal, participants were categorized as adherent (reported consuming 85%–115% of the weekly goals) or non-adherent (reported consuming <85% or >115% of the daily goals) on a daily basis. If there were no records from Lose It!, adherence to energy intake goals was coded as non-adherent for that day. For the analysis, we calculated the number of days that the participant was adherent to the energy intake goal.

One way to determine adherence to self-monitoring is to compare the recorded calories with the goal calories. Adherence to self-monitoring for each day was defined as recording ≥ 50% of the daily calorie goal. Non-adherence to self-monitoring for each day was defined as recording < 50% of the calorie intake goal or no recording of food intake. The number of days adherence to self-monitoring was calculated for each week.

Average steps per day were calculated from accelerometer data at baseline, 6 and 12 months. Participants were instructed to wear the accelerometer (ActiGraph GT3x) for ≥ 3 weekdays, one weekend day, ≥10 hours/day at each assessment period. Adherence to the energy expenditure goal was defined as ≥7500 steps per day.

3.3.3 Statistical analysis

Descriptive statistical analyses were conducted using SPSS software (version 22, SPSS Inc., Chicago, IL) for Windows. Statistical significance was set at .05 for two-sided hypothesis testing. Continuous variables (percent changes in weight, age, education, BMI) were reported as mean with standard deviation. Categorical variables (gender, race, employment, and household income) were reported as frequency, counts and percentages.

The group-based trajectory modeling (Nagin, 1999) using PROC TRAJ in SAS version 9.3 (SAS Institute, Cary, NC) was used to identify distinct classes of trajectories of self-weighing over 51 weeks. Once the final group-based trajectory model was identified, the resulting predicted group membership was treated as a grouping variable. Chi-square test of independence and general linear modeling were performed to examine the differences in time-invariant demographic categorical and continuous data, respectively, among the levels of the predicted group membership. Random coefficient models using PROC MIXED in SAS, assuming normal error, were used to examine the differences in time-dependent variables of adherence to energy intake, steps, and self-monitoring of dietary intake among the levels of the predicted group membership. Model checking was performed using information criteria (e.g., AIC, BIC) and viewing the graphs of residuals from the fitted models. The distribution of residuals was not normal; therefore, generalized linear mixed modeling assuming binomial error distribution was performed using PROC GLIMMIX in SAS. Sensitivity analyses were conducted for possible influential cases identified as outliers through graphical methods. The conclusions did not change when outliers were omitted, which, supported the robustness of our findings. Hence, the random coefficient models based on the full sample were reported.

3.4 RESULTS

The total sample for analysis was 148 participants since data for three participants were excluded because two of them were pregnant during the first 2-3 months of the study and one participant withdrew from the first day of study. The sample was 90.5% female, 81.1% Non-Hispanic White, 62.2% married or cohabiting, 72.3% had a household income >$50,000, with a mean age (SD) of 51.3 (10.1) years, and had completed average 16.4 (2.8) years of education and had a mean BMI of 34.1 (4.6) kg/m^2 at entry.

On average, self-weighing frequency declined from 5.8 to 4.8 days/week over 12 months. Further analysis was conducted using group-based trajectory modeling to identify distinct classes of trajectories based on the number of days participants self-weighed. Three patterns of self-weighing were identified in this sample (Figure 6): *high/consistent* (75.0% self-weighed more than 6 days/week regularly); *moderate/declined* (16.2% declined from 4-5 to 2 days/week); *minimal/declined* (8.8% declined from 5-6 to 0 days/week).

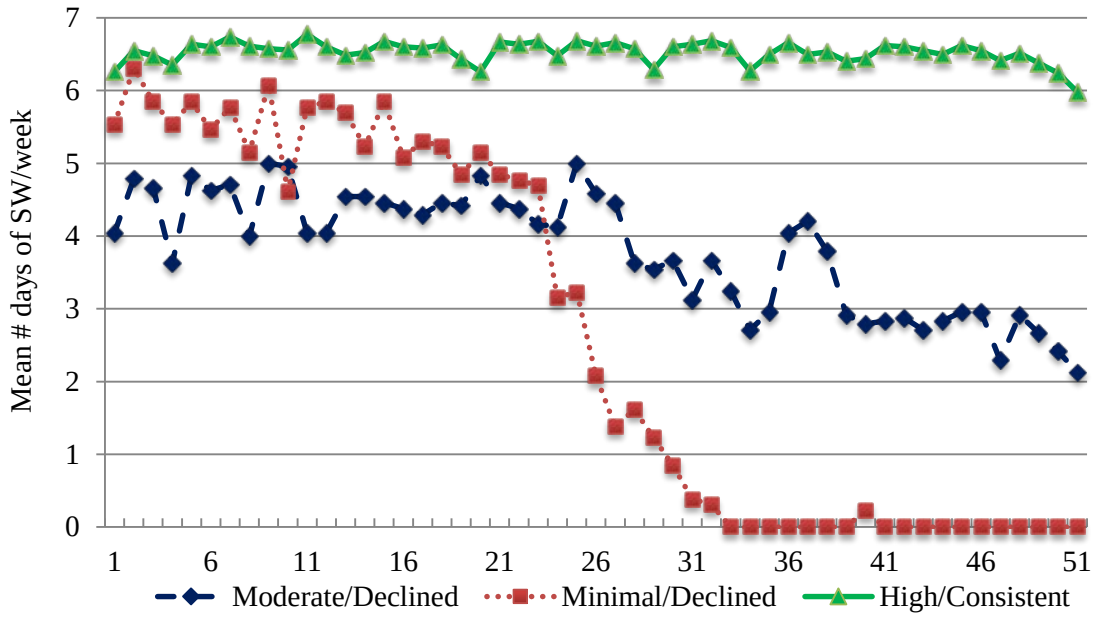


Figure 6. Patterns of Self-Weighing Behavior

There was a significant difference in ethnicity across three self-weighing trajectory groups (p=.001), with more Asian and white individuals demonstrating a high/consistent self-weighing pattern than black individuals (100.0 vs.79.2% vs.52.0%), and fewer Asian and white individuals following minimal/declined self-weighing pattern than black individuals (0.0% vs. 4.2% vs. 32.0%). However, there were no differences in baseline BMI, age, and years of education, gender, marriage status, employment status or household income level by self-weighing trajectory groups (Table 1).

Table 1. Demographic Characteristics by Self-weighing Trajectory Groups

	High/consistent (n=111)	Moderate/declined (n=24)	Minimal/declined (n=13)	F/x^2	p-value
BMI (kg/m^2), mean ± SD	34.1 ± 4.5	33.9 ± 4.7	34.3 ± 5.6	0.03	.97
Age (year), mean ± SD	51.9 ± 9.6	49.4 ± 10.8	49.8 ± 13.0	0.72	.49
Education (year), mean ± SD	16.6 ± 3.0	16.4 ± 2.2	14.9 ± 2.3	2.00	.14
Gender, % (n)				1.25	.56
Male	11 (78.6)	3 (21.4)	0 (0.0)		
Female	100 (74.6)	21 (15.7)	13 (9.7)		
Ethnicity, % (n)				15.70	.001
White	95 (79.2)	20 (16.7)	5 (4.2)		
Black or African American	13 (52.0)	4 (16.0)	8 (32.0)		
Asian	3 (100.0)	0 (0.0)	0 (0.0)		
Marital Status, % (n)				7.42	.61
Currently Married/ Living with Partner/ Significant Other	70 (63.1)	15(62.5)	7(53.8)		
Never Married/Widowed/ Separated/Divorced	40 (36.9)	9 (37.5)	6 (46.2)		
Employment Status, % (n)				5.99	.90
Full Time	91 (74.6)	20 (16.4)	11 (9.0)		
Non-Full Time	11 (78.6)	4 (83.6)	2(81.0)		
Annual Income, % (n)				3.41	.20
< $50,000	24 (21.6)	6 (25.0)	5(38.5)		
≥ $50,000	81(73.0)	18(75.0)	8(61.5)		

When we examined weight change, we found that the *high/consistent* group lost 10.19% at 6 months and 9.90% at 12 months. The *moderate/declined* group lost on average 5.45% and 5.62% weight at 6 and 12 months, respectively. The *minimal/declined* group lost 2.00% of baseline weight at 6 months but regained 0.65% over their baseline weight at 12 months. There was a significant group difference on percent weight change by self-weighing trajectory groups (p<.001) (Figure 7).

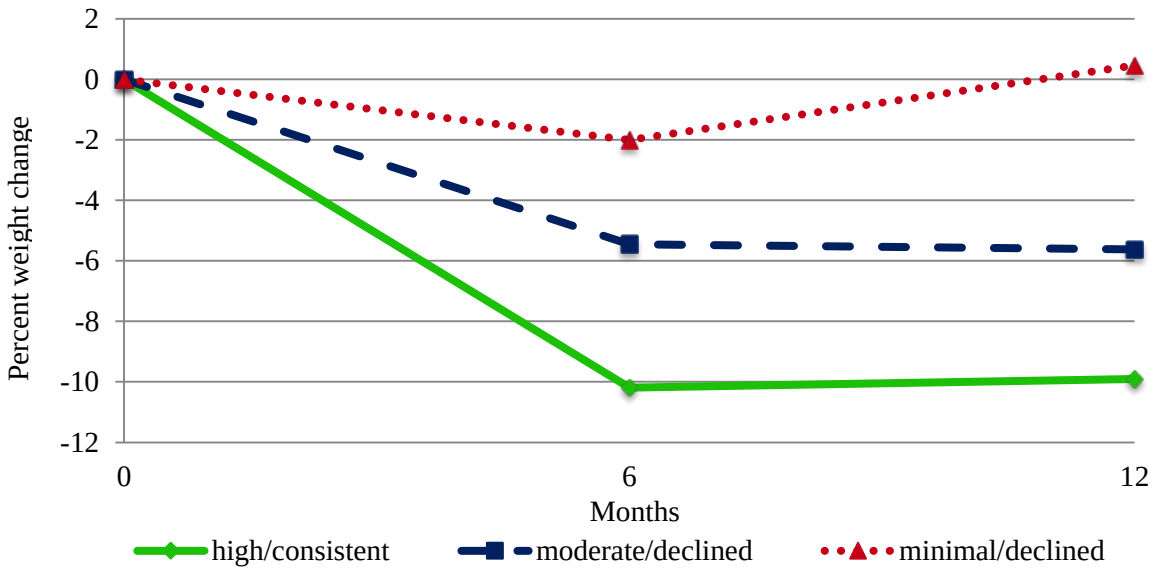


Figure 7. Changes in Weight by Self-Weighing Trajectory Groups

Regarding differences in adherence variables by self-weighing trajectory group, there was a significant interaction effect (self-weighing trajectory group × time cubic) on adherence to calorie intake goal (p=.009); the high/consistent group had a higher mean number days/week of adherence to calorie intake goal than the minimal/declined groups (t=5.83, p<.001) but not higher than the moderate/declined group (t=1.71, p=.09) (Figure 8). Similarly, there was a significant interaction effect (self-weighing trajectory group × time cubic) on adherence to self-

monitoring of dietary intake (p<.001) (Figure 9); the *high/consistent* group had higher mean number days/week of adherence to self-monitoring of dietary intake than the *moderate/declined* group (t=3.10, p=.002) and *minimal/declined* group (t=4.85, p<.001). There was a significant group effect on adherence to step goal (p=.02), the *high/consistent* group had higher probability of being adherent to the step goal than the *minimal/declined* group (t=2.68, p=.008) but not higher than the *moderate/declined* group (t=1.09, p=.28). Since there was no significant group × time effect, we dropped the interaction term and only reported the group effect and time effect for adherence to step goal (Table 2).

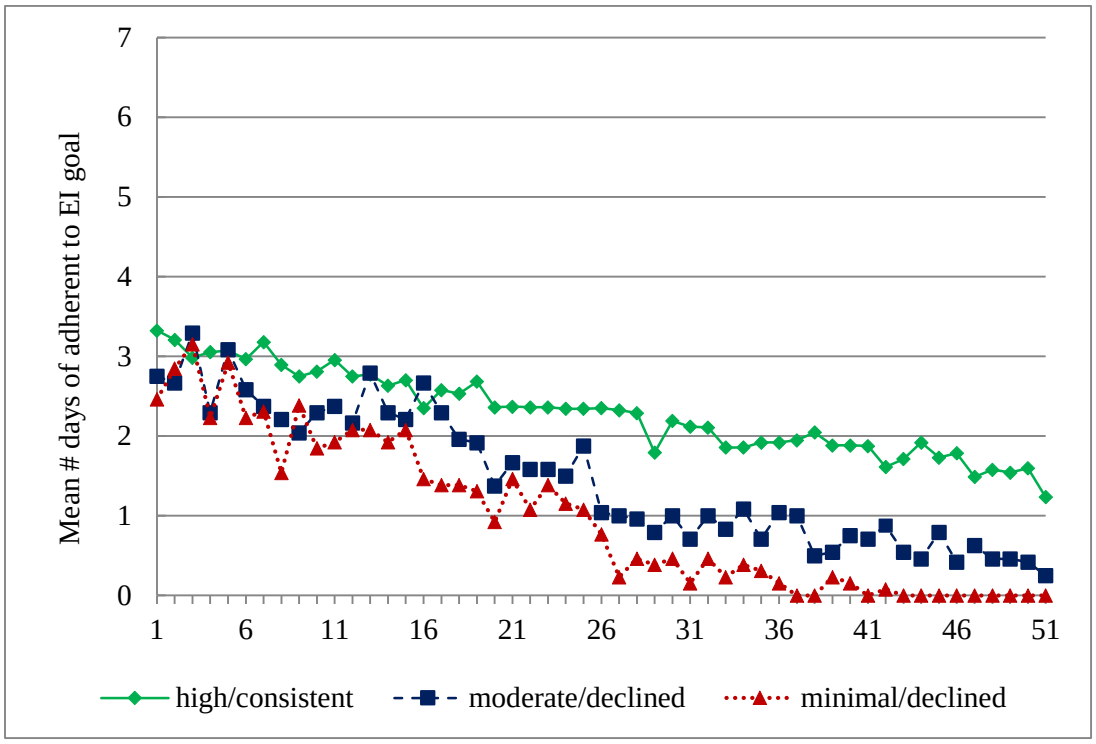


Figure 8. Number Days of Adherent to Energy Intake Goal by Self-Weighing Trajectory Groups

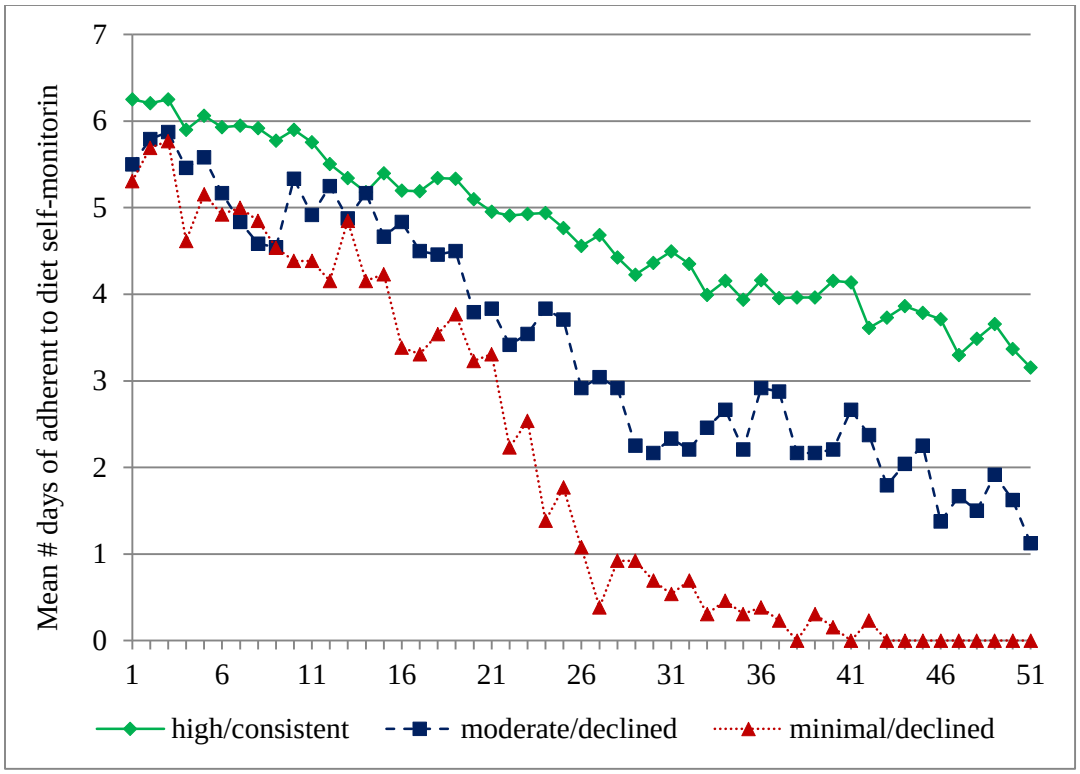


Figure 9. Number Days of Adherent to Diet Self-Monitoring by Self-Weighing Trajectory Groups

Table 2. Differences in Percent of Sample Adherent to Step Goal by Self-weighing Trajectory Groups

	High/consistent (n=111)	Moderate/declined (n=24)	Minimal/declined (n=13)	p-values	
				Group	Time
Baseline	25 (22.52)[a]	4 (16.67)	2 (15.38)	.02	<.001
6 months	52 (46.85)	8 (33.33)	0 (0.00)		
12 months	22 (19.82)	4 (16.67)	0 (0.00)		

Note: a = n (%)

3.5 DISCUSSION

This is the first study to identify and report three distinct patterns of self-weighing behavior over 12 months of a behavioral intervention for weight loss, with a majority of participants sustaining a habit of daily self-weighing. The *high/consistent* group that consistently self-weighed more than 6 days/week achieved greater weight loss and weight maintenance. The *high/consistent* self-weighing group also demonstrated greater adherence to calorie intake and step goals as well as adherence to self-monitoring of dietary intake. However, our data demonstrated that one fourth of the study's sample was not able to establish a habit of daily self-weighing.

Our findings reveal that the *high/consistent* self-weighing participants achieved a clinically meaningful weight loss (e.g., a loss of 5% of baseline body weight, which was significantly greater than those who did not establish the daily self-weighing habit. Steinberg et al. conducted a behavioral weight loss study focusing on daily weighing and used a smart scale that displayed current weight and transmitted the data directly to a website (www.bodytrace.com) via the wireless cellular network (Steinberg et al., 2013).Their results were similar to ours in that individuals who weighed every day over 6 months achieved significantly greater weight loss than those weighing less often. However, their study was only 6 months duration and did not report self-weighing patterns over time. Typically, individuals regain weight after an initial weight loss in a short-term weight loss study, e.g., 6 months (Butryn et al., 2011; Katan, 2009). Another study examined temporary associations between adherence and nonadherence to daily self-weighing and weight changes by analyzing longitudinal self-weighing data in a health-promoting program (Helander, Vuorinen, Wansink, & Korhonen, 2014). The study found that weight loss took place during periods of daily self-weighing, whereas self-weighing breaks longer than one month posed a risk of weight regain (Helander et

al., 2014). They also found that the more consecutive days without weighing, the larger the weight regain (Helander et al., 2014). Our study adds to these findings by examining the patterns of self-weighing over 12 months and revealing that individuals who established a daily self-weighing habit had greater weight loss and weight maintenance. We also found that the likely reason for achieving a weight difference might be that *high/consistent* self-weighers had greater adherence to other lifestyle behaviors (e.g., daily calorie intake goal) compared with those who did not establish the habit of daily self-weighing, which is consistent with what Steinberg and colleague reported (Steinberg, Bennett, Askew, & Tate, 2015).

We observed that 25% of participants did not self-weigh every day over 12 months including 16.2% of them whose self-weighing behavior declined to 2 days per week; 8.8% of them stopped using scales during the study. This finding indicates that it is important to identify barriers to daily weighing in these sub-groups to help inform the development of interventions to enhance self-weighing for a sustained period. We explored the factors influencing the different patterns of self-weighing. There were no differences in baseline BMI, age, and years of education, gender, marital status, employment status or household income level by self-weighing trajectory groups. However, the percentage of sample among ethnicity categories was different across the self-weighing trajectory groups. There were more Asian and white individuals following a *high/consistent* self-weighing pattern than black individuals. No published work has reported on reasons that a higher percentage of black vs. Asian and white individuals failed to weigh themselves daily. Therefore, another fruitful area of investigation would be to identify possible barriers that interfere with a subgroup of black individuals being less able to establish a daily self-weighing behavior.

The main limitation of the study is that the sample was well educated, white, and female, which precludes us from generalizing the findings to groups that represent males or less educated women. Another limitation is that adherence to the step goals was only assessed at three time points; therefore, we could not examine the patterns of this behavior changes by three self-weighing trajectory groups. Strengths of this study include the use of weekly prospective data which allowed us to explore pattern changes of self-weighing behaviors over time. This is the first study to identify distinct patterns of self-weighing behavior. Our work demonstrated that not all participants' self-weighing frequency declined overtime, which is distinctly different from previous findings that reported that self-weighing significantly declined over time (Helander et al., 2014; Steinberg et al., 2013; Y. Zheng et al., 2015. (Under 1st review)). Also, the findings from trajectory analysis provided insights into the longitudinal association between self-weighing patterns and weight changes. The second strength of this study is that self-weighing behaviors were objectively measured with a date-stamp, which eliminated the potential bias of self-reported weight data. Third, trajectory analysis could be applied to other behavior domains, e.g., dietary intake, physical activity, or medication adherence.

In conclusion, our work makes a significant and unique contribution to the literature related to self-weighing. Three distinct patterns of self-weighing behavior were identified over 12 months of a behavioral intervention for weight loss. Seventy five percent of participants were able to sustain a habit of daily self-weighing and achieved greater weight loss and weight loss maintenance. However, there was a subgroup of participants who could not establish the daily weighing habit. Thus, it is important to identify the barriers to this strategy in these sub-groups; doing so could help inform the development of interventions to enhance self-weighing for a sustained period. Building on the use of the Wi-Fi scales and its delivery of data in real time,

future consideration could be given to delivery of feedback and adherence-enhancing messages in real time.

4.0 MANUSCRIPT 3: EXPERIENCES OF DAILY WEIGHING DURING A 12-MONTH WEIGHT LOSS PROGRAM

4.1 ABSTRACT

Background: Little is known about individual experiences of daily weighing. The objectives of this study were to 1) describe participants' experience of daily weighing, and 2) explore factors influencing adherence to daily weighing within a behavioral weight loss study.

Methods: We conducted a qualitative study using focus group methodology. Participants were individuals who had completed a 12-month weight loss intervention that included daily self-weighing using a Wi-Fi scale; individuals were selected regardless of their frequency of self-weighing.

Results: The sample (N=30) was predominantly female (83.3%) and White (83.3%) with a mean age of 52.9±8.0 years and mean BMI of 33.8±4.7 kg/m^2. Five main themes emerged: 1) reasons for daily weighing, 2) reasons for not daily weighing, 3) factors that encouraged weighing, 4) recommendations for others about daily weighing, and 5) suggestions for future weight loss programs. The reasons for daily weighing included: feeling motivated, providing feedback for eating and exercise behaviors, and feeling under control. The reasons for not weighing daily were: feeling frustrated when weight increased, experiencing barriers to daily weighing due to travel, vacation, or interruption of routine. Participants reported that the following factors

encouraged daily weighing: it is simple, easy, and efficient; scale is reliable; weight is automatically recorded; weight reading is synchronized with smartphone app and graphically displayed. Participants suggest that individuals need to accept the fluctuations of daily weight.

Conclusions: Our results identified several positive aspects to daily self-weighing, which can be reinforced to promote adherence to this important strategy.

4.2 INTRODUCTION

Self-monitoring dietary intake and physical activity is the cornerstone of standard behavioral treatment (SBT) for weight loss (Burke, Wang, et al., 2011; Cooper & Fairburn, 2001). Since the late 1980s, evidence supporting self-monitoring has continued to accumulate (Baker & Kirschenbaum, 1993; Boutelle et al., 1999; Burke, Conroy, et al., 2011; Burke et al., 2009; Cooper & Fairburn, 2001). In recent years, self-monitoring of body weight has been added to the treatment protocol for weight loss (VanWormer et al., 2012; VanWormer, Martinez, Martinson, et al., 2009; R. R. Wing et al., 2006). More recently, it has been added to the treatment guidelines for weight management (Jensen et al., 2013; National Institute of Health. National Heart Lung and Blood Institute, 1998).

However, investigators raised concerns about how fluid intake, hormonal and menstrual changes, and other factors could obscure the temporal relationship between eating and weight changes, and also that daily weight could vary widely over time (Heckerman et al., 1978). Subsequently, Ogden and Whyman reported that participants in a daily weighing group showed increases in anxiety and depression and lowered self-esteem compared to those in the non-

weighing group (Jane Ogden & Whyman, 1997). Consequently, daily weighing was rarely mentioned in the literature as a strategy for weight loss prior to 2006.

Subsequent cross-sectional analyses demonstrated that a higher proportion of successful weight losers and weight maintainers weighed themselves daily (Klem et al., 1997; Kruger et al., 2006). A prospective study based on self-regulation theory reported that daily weighing was significantly associated with successful weight loss maintenance (R. R. Wing et al., 2006) and was not associated with negative psychological consequences (Rena R. Wing et al., 2007). Thus, daily weighing began to be reconsidered as a useful strategy for weight loss and maintenance. More recently, there has been an increase in prospective studies on daily weighing, which have demonstrated the consistent association between daily weighing and greater weight loss (Steinberg et al., 2013; Welsh et al., 2009), successful weight loss maintenance (C. R. Pacanowski & Levitsky, 2015; Sherwood et al., 2013), prevention of weight gain (Levitsky et al., 2006; VanWormer et al., 2012; R. R. Wing et al., 2015) and an absence of adverse psychological outcomes (Gokee-Larose et al., 2009; Steinberg et al., 2013). Ongoing research continues to provide supportive evidence for daily weighing leading to better outcomes compared with less frequent weighing(Linde et al., 2015; Madigan et al., 2015).

However, little is known about perception and acceptance of daily weighing or about the personal and environmental factors that may influence adherence to this strategy. Thus, the purposes of this paper are to 1) describe participants' experience of daily weighing and 2) explore environmental and personal factors influencing participants' adherence to daily weighing.

4.3 METHODS

4.3.1 Study design

Focus group methodology was used to describe participants' experience of daily weighing including their acceptance of daily weighing, as well as their perceived benefits and barriers to daily weighing. Participants were enrolled in the EMPOWER study (L.E. Burke, R01HL107370), a 12-month weight loss intervention study delivering standard behavioral treatment over 24 group treatment sessions. The main purpose of the study was to use ecological momentary assessment to identify the antecedents to relapse-relevant events during intentional weight loss (e.g., temptations and lapses) by repeated assessments of behaviors and emotions in real time. Each participant was given a Wi-Fi scale that transmitted their weight in real time to the research server. Participants were instructed to weigh themselves daily in the morning at home during the 12-month weight loss intervention study.

4.3.2 Sample

All participants who completed the EMPOWER study were eligible for the focus group study. Eligibility criteria for the EMPOWER study included: (1) ≥ 18 years of age, (2) BMI between 27 and 44, and (3) not having participated in a weight loss program in the past three months. Individuals were excluded if they: (1) reported any condition that might confound study findings (e.g., diabetes, pregnancy, post bariatric surgery); (2) planned to become pregnant in next 12 months; (3) planned frequent travel, extended vacations or relocation in next 12 months; (4) were

receiving current treatment for a serious mental illness; (5) reported alcohol intake ≥ 4 drinks/day; or (6) were unable or unwilling to use a smart phone for EMA data collection.

Two weeks prior to the final assessment of the EMPOWER study, participants were contacted by email to inquire if they wished to be part of a focus group. If interest was expressed, we further explained the study and obtained consent to participate at the final assessment visit.

4.3.3 Data collection

We used a group interview format consisting of seven open-ended statements/questions that encouraged participants to discuss their experience of daily weighing during the weight loss study. Focus groups were conducted in a conference room in the School of Nursing Clinical Research Center. We conducted a total of three group meetings with an average of 10 participants in each group, ranging from 8-13. The group facilitator was a doctoral student with a master's degree in social work and previous experience in conducting focus groups. Two recorders were used to audiotape the sessions and an assistant took notes. We encouraged openness by informing participants that we would not judge their opinions or behaviors related to daily weighing. Participants were encouraged to share their thoughts and feelings about their experience of daily weighing during the 12-month weight loss treatment study. Each focus group lasted approximately 50 minutes. We explored several topics including acceptance and perception of daily weighing, the role of daily weighing, and perceived benefits of and barriers to adherence to daily weighing.

4.3.4 Data Analysis

Data analysis followed standard procedures for coding qualitative data (Field & Morse, 1991). The recorded content was transcribed and accuracy was checked by a second person reading the transcript while listening to the audiotape. Following this the data were prepared for content analysis. Initial codes were identified, followed by code definition development and refinement. After a codbook was developed, two reviewers independently read and coded the transcripts and then met to compare the similarities and differences of coding. Differences were discussed among the reviewers or with experts in weight loss treatment research and/or qualitative research methods until consensus was reached.

4.4 RESULTS

The sample (N=30) was predominantly female (83.3%) and White (83.3%) with a mean age of 52.9±8.0 years and mean BMI of 33.8±4.7 kg/m^2. The mean frequency of self-weighing in this group was 5.1 days/week at baseline, which declined to 4.6 days/week at 12 months. A total of 25 (83.3%) participants consistently used daily weighing over the 12 months, while five (16.7%) showed a moderate declined in mean number of days of self-weighing. Mean percent weight change was -10.6% ± 6.0% at 6 months and -11.4% ± 8.1% at 12 months. Among these 30 participants, 29 strongly preferred to weigh every day during the study and thought daily weighing was very helpful.

Five main themes reflecting the participants' experience of self-weighing emerged. The themes included: 1) reasons for daily weighing, 2) reasons for not weighing, 3) factors that

encouraged weighing, 4) recommendations to others about daily weighing, and 5) suggestions for future weight loss programs, including changes or revisions to the current program. There were several sub-themes for each main theme.

4.4.1 The reasons for daily weighing

Feeling motivated. Most participants mentioned that they were motivated to continue daily weighing when the number on the scale was decreasing. The weight loss revealed by self-weighing motivated them to go to the gym and eat correctly. One participant felt that she had wanted to quit exercising, but once she began anticipating her weight decrease on the scale, she exercised more.

I would be motivated to exercise more…when I didn't really want to do it anymore, I would think, well, tomorrow it's going to show up, you know, and then I started running…this is going to be so good tomorrow; it's going to be so much better….

Some participants also mentioned that daily weighing motivated them to achieve small weight loss goals.

I think for me, I, I created a lot of mile posts along the way, so there were a lot of, sort of, mini goals. And the daily weighing would help me, sort of, track those…

During weekends or holiday periods, some participants expressed concerns that they might gain weight, but they felt pleasantly surprised that things were not as bad as they feared when they stepped on the scale. This was encouraging and motivated participants to return to healthier eating and activity after a holiday or weekend. Sometimes, when they reached a difficult point, such as a weight loss plateau, participants regained momentum when they reviewed the history of their progress.

Providing feedback on food intake and exercise. Participants mentioned that daily weighing influenced their food choices and the level of physical activity for a particular day. The feedback provided by daily weighing allowed participants to reflect on how their eating choices corresponded with their change in weight. Participants were able to reflect on what they had recently eaten and think about situations where they did well and ones where there was room for improvement (in eating behavior). Participants were then able to identify specific foods or lack of adherence to planned eating that may have caused the increased weight.

…I think that the fact that you have to stand there for what may be a minute, I do a lot of reflecting in that minute…

…it became very educational. If I ate and then I [my weight] was up the next day, and I would think back what I ate and I'd say, oh yeah, I shouldn't have had those pretzels.

…well, you know, I went up, well, was it because I had pizza last night, or was it the Chinese food, or was it the extra salt, or was it the three beers?

Participants reported three main benefits from daily or regularly self-weighing. 1) Increasing awareness of what they ate all day long to make sure their weight did not increase when they stepped on the scale the next day. They were especially more aware during holiday periods and the winter season. For example, *"…I gained like two or three pounds, but I thought that's really good because usually over the winter you would gain even more. And so that was nice…."* 2) Validating eating and exercising behaviors was another benefit of regular self-weighing. The participants realized that the effect of whatever they ate or physical activity they did or did not do was going to show on the scale the next day, *"I thought it [the scale] was wonderful because you could see immediately the effects of Chinese food, or [laughs], Thai food,*

or beer, pizza, popcorn." 3) Lastly, participants expressed that they learned how to make adjustments to their eating or exercise behaviors when self-weighing regularly: *"I just noticed its immediacy, as soon as I looked at the number on the scale I was already thinking about well what can I have for dinner tonight which is lower in calories…."*

One participant summarized these three benefits of daily self-weighing when she stated,

…, before this time …I ate pretty much anything and didn't really think about it. And it [daily-weighing] did make me much more aware… I really want that Hershey bar 'cause I knew what was going to happen if I ate the Hershey bar ..., if I was going to eat the wrong thing it was going to show up the next time, the next morning on the scale, 'cause first thing in the morning I would weigh myself.

Being in control. Participants felt in control of their behavior when they weighed themselves daily. They felt 'grounded' and expressed that starting the day knowing their weight and progress toward weight goal attainment helped them remain adherent to their eating and physical activity plan. One participant commented, "*it is control and you [are] master of your own destiny. Cause you can only control what you're going to see on there, so I am solely responsible, I can't put it on anybody else."* Another participant mentioned how daily weighing helped her control her weight gain during a more indulgent time of the year.

These past couple of days, because of the holiday, I ate more than I typically did; I ate foods that I typically don't put in my mouth like ice cream, a piece of pie, and when I got on that scale, I fully expected that number to be up, and it was up by two pounds…I knew that I was going to see it; I was prepared for it, but I didn't got [sic] that out of control either over the past couple of days because I knew I didn't want to see five pounds on the scale.

Some participants mentioned that they felt panic if they did not weigh daily. Participants noted that they would have this feeling without the feedback and reassurance that daily weighing provided if, for example, they did not have the scale with them when they were traveling.

I weigh myself every day and first thing in the morning, I still do it today. The only time I didn't take it on vacation with me was when I flew. … I flew to Florida, and I didn't have it with me, and I panicked almost because I didn't know what I was doing, you know. I didn't have that constant reminder of where I was…. But I was okay when I got back….

Participants felt under control not only at the weight loss phase, but also at the maintenance phase. During the maintenance period, some participants' weight might not have decreased dramatically or they might have even regained a little weight, but they still continued daily weighing because they thought they would be out of control and might regain much more.

I am trying to maintain…I'm forcing myself to still get on the scale. …I'm having a tough time, but I'm thinking…my weight would have gone up like really drastically if I wasn't still getting on that scale every day. It has helped me.

Being in a routine/habit. Participants reported that since they weighed every day, usually in the morning, it became a normal part of the routine and helped them to look at patterns of weight, rather than just fluctuations. There also were several participants who mentioned that, while they like weighing every day, they might miss a day once a week. However, in general, they still thought weighing every day was a useful routine.

I like weighing every day ...I ate out last night, if I always weighed on Saturday morning… I'm not gonna weigh on [this] Saturday morning, I'm gonna weigh on Sunday (laughs) because I know I ate out and I overate… Whereas, if it's every day, it's every day. So I was much more faithful… I wasn't afraid. I didn't. The reason I play games in my head with once a week is because I'm afraid of what I'm gonna see, and if you do it every day, how bad could it be in one day? So I'm not afraid of the scale, so it doesn't become a judgment, it's just information.

4.4.2 Reasons for not weighing daily

Interruption of routine. Some participants stated they did not weigh themselves if their daily routine was interrupted, for example, by holiday periods or weekend activities. In addition, some participants did not get on the scale if they thought that they might gain weight due to the interruption of their routine or if they overate during the weekends or holiday periods.

"…. you know, there's some days where I know I hadn't been particularly, um, faithful to healthy eating the day before, so I would like not, maybe, step on the scale until after my morning run or something."

The most frequent reason participants reported for not weighing was vacation or travelling. However, some participants did mention that they packed the scale and took it with them when travelling. Shift work, life events or life stress also disrupted the daily-weighing habit, as noted in the following:

I ran into problems only when my schedule changed dramatically. If there is a day of [the] week where I get up before or around four and my usual time is seven, it's just, sometimes, I was so tired at four in the morning - I don't know how you do it every day. Um, or I just kind of forget because of schedule change.

I've lost my job, my mother's parents both died whom I was close to, and, this spring, and I'm still grossly underemployed, and moving to a new house this past fall. You name it, all this stuff going on in my life, and, I'm an emotional eater, so when tough tough going gets tough [when the going gets tough], I turn to food… the scale's been like kind of my enemy in the corner…

Gaining Weight. A small number of participants expressed emotional reactions to weight gain. Among our 30 participants, five of them felt frustrated and one felt ashamed when she gained weight. Participants expressed feeling frustrated when their weight did not decrease in spite of efforts made to lose weight. One participant reported, "*… I noticed that really frustrated… you can do everything right and watch what you eat, start walking; doing everything, you know measuring at the same time every day….*" Some participants kept a positive attitude even though they were experiencing negative emotions.

…when it went up I would get disappointed in myself and it would still motivate me to stay on track and you know really count what was going into my mouth.

4.4.3 Factors that encouraged daily weighing

Participants reported that the following factors facilitated daily self-weighing: daily weighing is simple and not time consuming; weight is automatically recorded; scale is reliable; and weight reading is synchronized with a smartphone app and graphically displayed.

Participants reported finding it easy to use the Wi-Fi-enabled scale for daily weighing because of how it linked electronically to other devices (e.g., Lose It!) and did not require the participants to record their weight elsewhere. Participants mentioned that without the technology that automatically recorded their daily weight on Lose It!, they might not be weighing daily. Additionally, participants reported that daily weighing is efficient because it is only once a day and takes only one minute.

Participants were also pleased that the scale is reliable and precise down to the first decimal, which encouraged participants to get on the scale. One participant noted: *"I lost 0.1; you know, that is something. Or, oh, I only gained 0.1. That's not so bad."* Some participants

were particularly interested in the feature that synced with the phone because they could go back to review their previous weights up to an entire year and see if they made good progress.

4.4.4 Participants' recommendations to others about daily weighing

Acceptability of normal range of fluctuations. When we asked participants recommendations about daily weight, they recommended the need to accept the weight fluctuations when one weighs daily.

With the huge caveat, you have to understand how it'll fluctuate because it just isn't productive if your feelings are hurt and you're confused,

You have to understand that there are fluctuations. Sometimes are not necessarily good or bad things. I mean, there's sometimes I had no clue why it would vary as much as it did. And you have to learn to accept that there's a certain amount of weight that's gonna change every day and that's fine, you're looking more for a trend, you're looking more for long term….

Participants noticed that it is rare that the number was the same each day; it was either up or down a little bit. It did not matter if it increased as long as it went down overall since the scale provides information and is not a judgment. Participants also expressed that it was important to think about the trend or the graph of daily weight rather than the actual numbers (or weight). When participants realized that fluctuations were normal, even when they were adherent to their eating and activity plan, they found it easier to avoid negative responses to a small weight gain.

…I realized, while I was losing weight, that it always changes. It goes up a little bit, it goes down a little bit, but it always goes down a little bit more. … so I knew that there was a pattern. So, it wasn't that frustrating. I knew as long as I kept doing what I was supposed to do,

it was going to go up a little bit, down a little bit and then that one number was going to disappear. And then this would be the new number, and then it would go up and down from that number.

In the long run it was reassuring to me, because I would see those fluctuations, I would think I was eating consistently and I would still fluctuate, which means then I don't freak out when I fluctuate a little bit, because that's what my body does. So, it gives me information about how my body works and it's not always exactly to the tenth the same.

Additionally, some participants suggested that there were delayed effects of healthy food intake on weight change, and acknowledged the weight might not be an instant reflection of food choice the day before. As one participant stated,

It's also led me to really wonder about the mystery of weight gain and loss because sometimes when I ate well and exercised well, my weight went up. You know, what happened? But, anyhow, I thought it was very useful.

Other participants also noticed that some factors, e.g., water retention, prescribed medication use, might affect the fluctuation of weight in spite of eating well and being physically active. They did not feel surprised once they were clear that this could occur.

I found that it's very educational, because I used to think that it would just be like a straight line, and it's good to know that it's not, that there are many other factors that are contributing.

I did go to a baseball game on Sunday and I didn't weigh myself Monday because I ate so much ballpark food- salty popcorn. I didn't want to get depressed… So I did skip a day. I've

done that occasionally but then I realize, you got to face the music. If you know what you ate and you start to see a pattern. So maybe you don't feel so upset because you know that most of it was salt.

Self-weighing options. Most participants supported daily weighing because of the feedback provided. Several comments highlighted the concern that if one does not weigh daily, but does so only once a week and there is a sudden weight increase, it might be difficult to determine what caused the sharp increase due to the lack of information between weighing. Weighing daily was seen as a tool to identify the possible cause of the weight change.

…you can't just do it once a week… you would miss some of those trends that you would definitely miss those things like, oh my God, I went off the deep end for a three-day holiday, and not realize it. And then by that point, you might be five, six, eight pounds down the road, it's harder to recover from that… so the more regular the better, if you are serious.

I find it a very positive experience opposed to getting weighed once a week 'cause, you know- um, you knew right away where you were and you knew how you could get back under control. If you waited a week, sometimes there was more damage there, then you kind of just say, "ahh, forget it."

Participants also found daily weighing more effective than other common methods of assessing their current weight status.

Some people would say, you know, they don't weigh themselves, and you just depend on how your clothes fit, but I think it is way better to know right away, so you know right away whether what you should do 'cause, yeah, you could put on five pounds and think oh, you know, it wasn't that bad; I didn't gain that much. You know you just fool yourself. …Whereas, there is

no fooling yourself when you see that every day. …You're right; you could say it wasn't that bad… I didn't eat that much or it really didn't affect me that much.

Details important for optimal scale use. There were some important details participants expressed as necessary to achieve optimal use of the scale. 1) Place the scale on a hard surface. Participants found the scale was inaccurate if it was put directly on the carpet. *"I think that scale, did anybody put the rubber feet on? The big rubber rug feet? Well, I did because I thought, they're carpet feet, great, I can put it on my carpet, and then it didn't seem to weigh accurately at all. So I ended up putting it on a hard surface."* 2) Keep the scale in an open space. This way, it is easy to remember to weigh every day. *"Just put it somewhere where you know you'll see it every day…it's easy to have it in your bathroom or your bedroom or whatever, it's better to have it there, I think that helped, and you know, have it in your path."* 3) Allow the scale to recalibrate if moved. One participant found that when she moved the scale out from underneath the bed, she needed to make sure the scale was on a firm surface and wait a few minutes before checking her weight.

4.4.5 Suggestions for future weight loss programs

Provide more education on daily weighing experience. Participants expressed that it would be helpful for the interventionist to explain more about the use of the scale before their first experience, e.g. the potential reaction daily weighing may elicit, and why self-weighing should be daily. One participant expressed her thoughts the following way: *"…getting on the scale is a reality check. Hey, do you understand this is gonna happen? And we need to work through it, and, you know, make sure people keep getting on board because it's a, that's a big deal for me,*

especially since I go the other way." Especially, when people do not quite understand why they need to weigh every day.

… I was gonna sit there and tell my kids to do it you can learn from it. It wouldn't do them a lick of good unless I spent like fifteen minutes explaining to them: why you do it, how you do it, good things, bad things. You have to have that education around or it's not gonna, you would overreact at times with things, underreact other times at things.

Use daily weighing along with the other behavioral intervention strategies. Participants acknowledged the importance of using the self-weighing strategy along with the other recommended strategies for weight change, e.g., self-monitoring of calorie intake, setting up smaller and manageable goals, mastering problem solving skills and self-control skills.

The whole idea is of calories…if you really are having a problem with weight, if you're not counting calories, you're never gonna figure it out, you know. So, [scale] it's one of the tools but it's not the only tool, so people have to understand there are ways they can move it in a better direction if they use other tools.

4.5 DISCUSSION

We explored the experience of daily weighing with participants in a behavioral weight loss intervention. The majority of focus group participants expressed that daily weighing was an acceptable strategy in the context of an active weight loss program. They also viewed daily weighing as simple, easy, and efficient. Overall they benefited from daily weighing by feeling more in control of their weight, and using the results from the scale to regulate their eating and exercise behaviors.

Our results identified several positive aspects to daily self-weighing. Daily weighing enhances weight control by providing regular feedback to participants on the effects of their energy intake and expenditure. The feedback increased participants' awareness of their food choices and their physical activity for a particular day. Viewing the weight values over time permitted participants to validate their diet and activity choices made a few days earlier and then adjust their choices going forward. This behavior supported better weight maintenance. According to self-regulation theory, motivation for behavioral change results from the interplay among self-observation, recording, awareness, and self-evaluation (F. Kanfer & Goldstein, 1990). Our results provide evidence that regular self-weighing permitted the individual to increase awareness of weight change and its relation to energy intake and expenditure.

No participants expressed psychological distress as a result of daily weighing, e.g., body dissatisfaction, anxiety, or susceptibility to hunger. This is consistent with results reported from other quantitative studies (Steinberg et al., 2014; Rena R. Wing et al., 2007). Although some participants expressed frustration when their weight increased, we identified coping strategies that might help. First, providing education about the likelihood of weight fluctuation may be helpful to participants. Participants need to know that fluctuations could be due to changes in body fluid, body glycogen content, and the contents of the gastrointestinal tract (Heckerman et al., 1978). Second, the weight might not be an instant reflection of food choice; there might be a delayed effect of healthy food intake on weight change. Therefore, it is important to use daily weighing results as information rather than judgment.

The limitation of this study is that the majority of participants had consistent adherence to daily weighing, which may have biased our findings. We may not have obtained the opinions of participants who discontinued daily weighing during the behavioral weight loss treatment

program. A noteworthy strength of this focus group study is that it is the first reported study to use qualitative methods to explore and describe participants' experience of daily weighing as well as their perceived benefits and barriers to daily weighing in behavioral weight loss interventions.

In conclusion, our results identified several positive aspects of daily self-weighing, e.g. feeling motivated, providing feedback for eating and exercise behaviors, and feeling being in control. These aspects of daily self-weighing can be used to inform future interventions to reinforce and promote adherence to this important weight loss/maintenance strategy. Future studies need to use daily weighing as an additional dimension to support participants' self-regulation of their eating and physical activity behaviors and enhance weight loss and weight maintenance. In addition, exploring the role of daily weighing among males and more diverse ethnic populations is needed.

5.0 SUMMARY OF STUDY

We used data from the SELF trial to conduct an exploratory mediation analysis, the findings suggested that during the first 6 months of the study, there was a significant mediation effect of adherence to EI and EE goals on the association between adherence to self-weighing and percent weight change. Additionally, identifying clusters of individuals with distinct patterns of self-weighing could provide information on how the various patterns may affect weight loss as well as potentially inform interventions targeting individuals at highest risk of discontinuing regular self-weighing. The EMPOWER study used Wi-Fi-enabled scales to objectively measure self-weighing behaviors; this provided daily data and also allowed us to examine the self-weighing behavior patterns over a 12-month period. Therefore, we added a new study aim, using group-based trajectory modeling to identify patterns of self-weighing. The finding was unexpected that three patterns of self-weighing behaviors were identified. Seventy-five percent of the sample was able to sustain a habit of daily self-weighing and these participants achieved greater weight loss and weight loss maintenance than those who could not sustain the self-weighing habit. From the focus group study, four main themes were identified. Reasons for daily weighing included feeling motivated, obtaining feedback for eating and exercise behaviors, and feeling under control. Reasons for not weighing daily included interruption of routine and weight gain. The main factors encouraging daily weighing are simplicity, ease, and efficiency of electronic scale

use. The main suggestion for future users was learning to accept a normal range of daily weight fluctuation.

Findings from the trajectory analysis indicate that future research needs to investigate why individuals exhibit different patterns of self-weighing behavior, especially the factors that facilitate individuals in the high/consistent self-weighing group to establish a habit of daily weighing. Future studies also need to identify the differences among the three trajectory groups in certain psychological factors, e.g., self-efficacy and problem solving skills. The findings form these investigations can inform the development of interventions to improve adherence to daily self-weighing. Additionally, findings from mediation analysis and focus groups suggest that self-weighing impacts weight changes directly and indirectly through changes in dietary intake and exercise behaviors. Future work needs to consider developing interventions that may better assist participants to regulate their eating and exercise behaviors in response to daily weight and weight change trends. Finally, we need to explore the role of daily weighing among all population groups, particularly males, younger and older adults, and diverse ethnic populations.

APPENDIX A

SELF-WEIGHING IN WEIGHT MANAGEMENT: A SYSTEMATIC LITERATURE REVIEW

Review
CLINICAL TRIALS: BEHAVIOR, PHARMACOTHERAPY, DEVICES, SURGERY

Obesity

Self-Weighing in Weight Management: A Systematic Literature Review

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Objective: Regular self-weighing, which in this article is defined as weighing oneself regularly over a period of time (e.g., daily, weekly), is recommended as a weight loss strategy. However, the published literature lacks a review of the recent evidence provided by prospective, longitudinal studies. Moreover, no paper has reviewed the psychological effects of self-weighing. Therefore, the objective is to review the literature related to longitudinal associations between self-weighing and weight change as well as the psychological outcomes.
Methods: Electronic literature searches in PubMed, Ovid PsycINFO, and Ebscohost CINAHL were conducted. Keywords included overweight, obesity, self-weighing, etc. Inclusion criteria included trials that were published in the past 25 years in English; participants were adults seeking weight loss treatment; results were based on longitudinal data.
Results: The results ($N = 17$ studies) revealed that regular self-weighing was associated with more weight loss and not with adverse psychological outcomes (e.g., depression, anxiety). Findings demonstrated that the effect sizes of association between self-weighing and weight change varied across studies and also that the reported frequency of self-weighing varied across studies.
Conclusions: The findings from prospective, longitudinal studies provide evidence that regular self-weighing has been associated with weight loss and not with negative psychological outcomes.

Obesity (2015) **23**, 256-265. doi:10.1002/oby.20946

Introduction

The prevalence of obesity has been at an epidemic level in the United States for over a decade (1,2). Approximately two thirds of adults are overweight (BMI of 25-29.9) or obese (BMI $\geq$ 30) (3). Considering the numerous comorbid conditions that are associated with obesity, this is a serious public health problem that has major implications for longevity, quality of life and healthcare costs (4).

Standard behavioral treatment (SBT) is the most efficacious non-medical treatment for overweight or obese individuals (5,6). It is an approach that combines instruction about nutrition and exercise with strategies that facilitate behavior change (7). The core behavioral change strategies of SBT for weight loss include goal setting, self-monitoring, cognitive restructuring, self-efficacy enhancement, and development of problem-solving skills (8).

Self-monitoring is the cornerstone of behavioral treatment for weight loss (9-11). It is a method of systematic self-observation and recording of target behaviors with the goal of increasing self-awareness (12,13). A significant association has been demonstrated between self-monitoring of dietary intake (e.g., calorie content, portion size) and physical activity (e.g., exercise minutes, walking steps) and successful weight loss and weight loss maintenance. Specifically, frequency of self-monitoring (i.e., on a greater number of days) is significantly associated with weight loss (11,14-21). Burke et al. have demonstrated that timing related to self-monitoring of eating is also significantly related to improved outcomes, suggesting that the closer one records dietary intake information to the eating event, the better the weight loss outcome (22,23).

Traditionally, self-monitoring has focused on recording dietary intake and physical activity; however, more recently, self-monitoring of weight or self-weighing has been introduced as another monitoring component (11). Self-weighing has also been recommended as part of the AHA/ACC/TOS Guidelines for Managing Overweight and Obesity in Adults from the National Heart, Lung, and Blood Institute (24). According to self-regulation theory, motivation for behavioral change results from self-monitoring and observing the comparison of currently recorded behavior to the desired state, as well as the interplay among awareness, self-observation, recording, and self-evaluation (25). Regular self-weighing, which in our article

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Disclosure: The authors declared no conflict of interest.
Received: 10 May 2014; **Accepted:** 1 October 2014; **Published online 17 December 2014. doi:10.1002/oby.20946**

is defined as weighing regularly over a period of time (e.g., daily, weekly), permits the individual to observe changes in weight and become aware of specific situations or patterns of eating or physical activity and how they are related to changes in body weight (26). These observations may motivate the individual to sustain behavior changes that support positive outcomes, or take corrective action for those that may lead to weight regain (27).

Early work suggested that self-weighing had no effect on weight loss (28) and daily self-weighing generated negative mood (e.g., depression, body dissatisfaction) (29). Subsequently, there was a common perception among clinicians and researchers in the weight control field that one should not recommend self-weighing as a weight loss strategy (30). However, recent cross-sectional studies have demonstrated that more frequent self-weighing is associated with successful weight loss (31-33) and lower BMI (34) in adults. A secondary analysis of two studies examining cross-sectional and longitudinal associations between self-weighing and weight demonstrated that daily weighing is valuable to individuals trying to lose weight or prevent weight gain (35). Moreover, a randomized clinical trial using an approach that was based on self-regulation theory found that daily weighing was significantly associated with successful weight loss maintenance (36), and was not associated with negative psychological consequences (37). In 2008, VanWormer et al. conducted a review of several self-weighing and weight management studies of varying designs and duration (38), and reported that self-weighing seemed to be a good predictor of moderate weight loss, less weight regain, or the avoidance of initial weight gain in adults. Since 2008, there has been an increase in the number of prospective, longitudinal studies on self-weighing. However, there has not been a published review of the recent evidence provided solely by prospective, longitudinal studies. Furthermore, the paper by Vanwormer et al. in 2008 did not review the psychological effects of self-weighing. Thus, the aim of this article is to review the empirical literature on the role of self-weighing in weight management among overweight/obese adults enrolled in longitudinal, prospective studies, specifically focusing on (1) the association between self-weighing and weight change, and (2) the association between self-weighing and psychological outcomes.

Methods

Search strategies

Literature searches were conducted in the electronic databases PubMed, Ovid PsycINFO and Ebscohost CINAHL. Keywords included "overweight," "obesity," "weight gain prevention," "self-weighing," "self-monitoring," "self-care," "weight monitoring," and "weight." Additionally, a manual search of the reference sections of the relevant articles was performed. Search limiters included English language and inclusion of human participants. Once we identified an important or influential article, cited reference searching strategy was used to find additional articles. Cited reference searching is a manual method to search for articles that have cited a previously published work and is a feature unique to the Web of Science database. Consultation with a research librarian with expertise in systematic reviews who guided us in the search strategies also occurred.

Inclusion and exclusion criteria

Inclusion criteria included trials that were: (1) published in the past 25 years, (2) used English language, (3) restricted to participants ≥18 years, (4) randomized controlled trials (RCTs) or ancillary to RCTs, and (5) inclusive of results based on longitudinal data. This review was restricted to trials in which self-weighing was included among the weight loss intervention strategies. There were no limitations on sample size, setting, duration of study or the country in which the study was conducted.

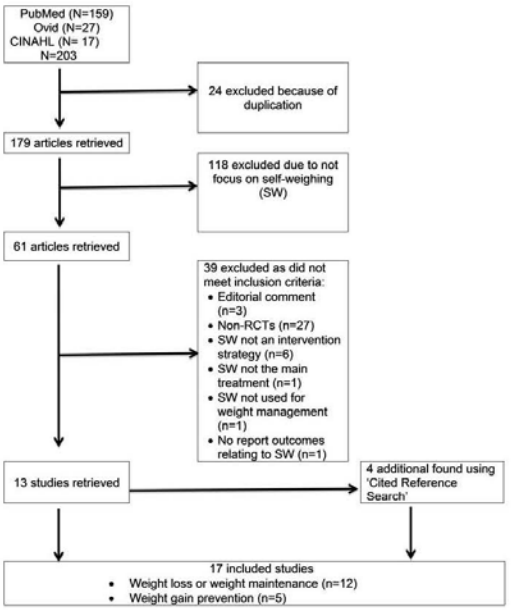

Figure 1 Inclusion/exclusion flowchart.

Data extraction

Of the total existing English language articles related to self-weighing, only 16 met our inclusion criteria. Of the 16 articles, we further excluded 3 RCTs, because self-weighing was not included among the weight loss intervention strategies (39), self-weighing was not used for weight management but only for recording weight (29), and the effects of self-weighing on outcomes were not evaluated (40). On the basis of the remaining 13 RCTs, we further identified 4 relevant studies using the Cited Reference Search strategy, bringing our total to 17 studies. The final 17 studies we reviewed included 12 articles related to weight loss or weight maintenance, and 5 articles related to weight gain prevention (see Figure 1). Studies were summarized based on the following categories: authors, study aims/design, sample size/characteristics, retention rate, intervention approach, self-weighing measurement and outcomes related to self-weighing (Tables 1 and 2). If the data were absent from the ancillary studies, the data from the parent studies were reported.

Results

Description of included studies

The increased interest in self-weighing as a treatment strategy is reflected in the increased number of research articles on this topic in recent years. Eleven of them have been published since 2008. Among the

TABLE 1 Studies on weight loss or weight maintenance

Authors	Study aims/design	Sample/retention	Intervention	SW measurement	Outcomes related to SW
Sherwood et al., 2006 (35,41); Linde et al., 2005 (35)	3-group, 10-lesson Tx, total 24-mo studies for WL and WM; 3 conditions: mail, phone intervention, and usual care (managed care).	$N = 1801$; 72% female; 91% White; age 50.7 ± 12.4; BMI 34.2 ± 6.0; retention 66.4%.	Int: SBT + SW (does not mention if giving Ps scale at home); instructions stated, "Some people find it helpful to self-monitor their weight regularly. If you choose to use this tool, we recommend that you weigh yourself no more than once a week." Con: usual care (managed care).	Self-reported by answering question "How often do you weigh yourself?"	Monthly, weekly, and daily SW were associated with WL at 12 and 24 mo ($Ps < 0.0001$); less frequent SW was associated with WG.
Wing et al., 2006 (36); Wing et al., 2007 (37); Wing et al., 2008 (42)	18-mo, 3-group study comparing effects of intervention via Internet, face to face, and no contact on WM.	$N = 314$; Internet group ($n = 104$): 82.9% female, age 52.0 ± 10.8, BMI 29.1 ± 5.0; Face to face group ($n = 105$): 80.8% female, age 50.9 ± 9.3, BMI 28.1 ± 4.6; Con ($n = 105$): 80.0% female, age 51.0 ± 10.3, BMI 28.7 ± 4.7; retention 92.7%.	Int: SBW + SW; Ps were given a scale and introduced to a weight-monitoring system based on color zones. They were taught to use the scale to determine adjustments in energy-balance behaviors. Ps submit weekly weight through an automated telephone system (face-to-face group) or a web-based form (Internet group). Con: basic weight control information without interaction with intervention staff and were seen at the clinic only for assessments.	Self-reported: Ps were asked to indicate how frequently they SW during the past mo using a 7-point scale ranging from (several times a day) to (never).	Daily SW: 28.9% to 40.0% in Con, 65.1% to 81.4% in Internet group, and 71.2% to 78.9% in face-to-face group. Daily SW ↑ in both Ints groups and associated with ↓ risk of regaining ≥2.3 kg (36). No evidence showed ↑ in frequency of SW or daily SW had adverse effects. Rather, ↑ in SW associated with ↑ in dietary restraint, ↓ in disinhibition, and ↓ in depressive symptoms. Those who SW daily at 18 mo were less likely to report having ≥4 binge episodes per mo (37).
Lally et al., 2008 (43)	3-group, 8-wk Tx; Int groups followed additional 6-mo study for WL and WM; Int (weekly vs. monthly SW) vs. Con.	$N = 104$; Int weekly ($n = 36$): 50.0% female, 78.0% White, age 43.3 ± 11.4, BMI 31.6 ± 5.5, retention (8 mo) 50.0%; Int monthly ($n = 33$): 54.5% female, 88.0% White, age 42.1 ± 9.9, BMI 31.7 ± 5.1, retention (8 mo) 30.3%; Con ($n = 35$): 77.1% female, 77.0% White, age 36.0 ± 9.8, BMI 29.5 ± 3.0, retention (8 mo) NA.	Int Ps were given a leaflet containing advice on habit formation and simple recommendations for eating and activity behaviors promoting negative energy balance, together with a self-monitoring checklist.	Self-reported: daily monitoring form.	At 8 wk, Int condition had significantly more WL than Con condition, with no difference between weekly and monthly SW subgroups. At 32 wk, those who remained in Int groups had lost an average of 3.8 kg, with 54% losing 5% or more of their body weight. An intention-to-treat analysis (based on last-observation-carried-forward) reduced this to 2.6 kg, with 26% achieving a 5% WL.
Gokee-LaRose et al., 2009 (44)	20-wk, 10-wk Tx, 10-wk follow-up, 2-group study comparing a behavioral self-regulation condition (BSR) and tailored SBT on WL and WM.	$N = 40$; 87.5% female; 75% Caucasian; age 29.1 ± 3.9; BMI 33.36 ± 3.4; retention 93%.	All received SBT. During the 10 weekly group meetings, BSR were given digital memory scales and were instructed to SW and use color zones, while SBT were not. After group sessions, SBT were encouraged to SW weekly at home but were reminded to place primary emphasis on their behaviors, not on their weight.	Self-reported: Ps in both groups self-reported frequency of SW at each time. Electronic recorded: BSR group were also required to bring the digital memory scale to clinic after 1 mo in the program and at post-treatment and follow-up.	At 10 wk, 95% BSR vs. 94% SBT SW daily. At 20 wk, 70.6% BSR SW daily vs. 17.6% SBT SW weekly; no SBT Ps SW daily. Positive association between frequency of SW and greater overall WC from baseline to follow-up. No negative psychological effects of daily SW, but positive changes in body image dissatisfaction, binge eating behavior, depressive symptoms, and eating disorder.

TABLE 1. (continued).

Authors	Study aims/design	Sample/retention	Intervention	SW measurement	Outcomes related to SW
VanWormer et al., 2009 (45,46)	18-mo, 6-mo Tx, 12-mo follow-up, 2-group study, but only analysis 12-mo data; comparing immediate to delayed methods on WL and WM.	$N = 100$; Immediate Tx: 93% female, 84% White, age 44.5 ± 9.2, BMI 39.2 ± 5.9, retention 13%; Delayed Tx: 93% female, 87% White, age 47.7 ± 8.0, BMI 37.6 ± 4.8, retention 38%.	Immediate group: 10 telephone counseling calls-based behavioral WL Tx + SW. Ps received a home telemonitoring scale, were instructed to SW daily, and received feedback from counsellors. Con: no Tx for first 6 mo, but received same Tx after 6 mo.	Electronic recorded: the device used an integrated modem and was connected to an analog telephone line, whereby information on weight was transmitted to telephone counseling staff daily.	Immediate group had significantly more WL relative to the delayed group over the first 6 mo (−7.5 vs. +1.3 pounds) (46). Ps who lost ≥ 5% of weight was significantly higher among individuals who SW ≥ weekly than those who SW ≤ weekly (46% vs. 8%). No significant differences were observed at the 12-mo follow-up visit (45).
Welsh et al., 2009 (27)	3-group, 6-mo phone-based WL Tx study; a 10-session vs. 20-session telephone counseling group vs. no contact self-directed group.	$N = 73$; 89% female; 82% White; age 49.5 ± 1.4; BMI 34.2 ± 0.5; retention 79.4%.	All Ps SW combined with SBT; Int group asked to report their weight weekly to their counselor.	Self-reported. At baseline and 6 mo, Ps reported SW frequency.	Ps who SW daily had more WL than Ps who SW ≤ weekly. Ps who increased their frequency of SW showed better WL outcomes than those who maintained or decreased their frequency of SW (−6.8 kg vs. −3.1 kg, $F = 8.59$, $P = 0.006$). Change in SW frequency was not associated with body satisfaction. Non-significant results were found for change in SW frequency and change in eating disorder.
Funk et al., 2010 (47)	3-group, 6-mo Tx, total 30-mo study for WL and WM; Internet vs. personal contact vs. self-directed Con.	$N = 348$ (data were analyzed from Internet arm); 63% female; 38% African American; age 55.7 ± 8.5; BMI 34.2 ± 4.9; retention 93%.	Internet group used an interactive website to self-monitor weight and enter information about diet, physical activity, and other WL activities (e.g., setting goals, making action plans, getting support). Ps were encouraged to log in at least weekly and enter a current weight for the 30-mo study period.	Self-reported through Internet, using the website consistently to track weight.	Numbers of weight entries were associated with less weight regain ($P = 0.002$).
Linde et al., 2011 (48)	6-mo, 2-group, 2-hour Tx followed by no further contact or 1 or 2 telephone reminders (weight- or behavior-focused).	$N = 68$; 72.7% female; 81.8% White; age 44.7 ± 11.2; BMI 31.1 ± 3.12; Retention 64.7% Int; 76.5% Con.	Int: behavioral weight control Tx + SW. Ps received a bathroom scale and were instructed to complete 24 weekly self-monitoring records, in the form of weekly postage-paid cards to be completed and returned by mail to the research team. Con: basic nutrition advice without interaction with intervention staff and were seen only for assessments.	Self-reported by answering question "How often do you weigh yourself?"	Int group ↑ SW frequency from baseline to 3 mo and 6 mo (7.6 vs. 25.5 vs. 19.3 days/mo), Con group (5.5 vs. 7.3 vs. 8.5 days/mo). WC in Int group was −0.72 ± 3.7 kg vs. −0.22 ± 0.23 kg in Con group.

TABLE 1. (continued).

Authors	Study aims/design	Sample/retention	Intervention	SW measurement	Outcomes related to SW
Kong et al., 2012 (49,50)	4-group, 6-mo Tx, total 12-mo study for WL and WM; Diet vs. Exercise vs. Diet + Exercise vs. No intervention.	$N = 143$ (123 data were analyzed on who completed study among Diet vs. Exercise + Diet groups); 79% female; 83.7% White; age 57.9 ± 5.0; BMI 31.3; retention 86.0%.	Int group received SBT and were encouraged to SW at home at least weekly for 12 mo.	Self-reported by asking, "How frequently do you weigh yourself? (on your own, not weighed by another person)" at 12 mo pertaining to the previous 6 mo.	At 12 mo, most Ps (88%) reported SW at least weekly; the response options were collapsed into 2 categories: daily or more ($n = 45$) and less than daily ($n = 78$). No significant difference in adjusted mean percent WC was observed in the "daily or more" vs. the "less than daily" group (49). SW daily or more did not differ by age, race/ethnicity, or marital status. Women with at least a college degree were less likely to SW daily compared with those with some college or less ($P < 0.01$) (50).
Sherwood et al., 2013 (51)	2-group, 24-mo study for WM; adults who had recently lost >10% of their body weight and were randomized to the "Guided" or "Self-Directed" intervention.	$N = 419$; 81.6% female; 91.2% White, age 46.4 ± 10.7; BMI 28.4 ± 5.0; retention 86.9%.	All Ps self-monitored their eating, physical activity, and weight. Guided Ps received a 10-session workbook, 10 biweekly, 8 monthly, and 6 bimonthly phone coaching calls, bimonthly weight graphs, and tailored letters based on self-reported weights. Self-Directed Ps received the workbook and 2 calls.	Self-reported: SW frequency was obtained at baseline, and at 12-, and 24-mo follow-ups, by means of a survey item with 7 possible frequencies, ranging from "never" to "every day"; SW was categorized as occurring "at least once a day" or "less than once a day."	Ps reported that they SW daily in 1029 of the 1932 (53.8%) baseline or follow-up surveys. This included 191 Ps responses in both Tx groups (51.6%) at 24 mo. Odds of reporting daily SW at 24 mo were 1.97 (95% CI: 1.31-2.99) times greater in Guided compared to Self-Directed group, with about 60% of Guided Ps reporting daily SW compared to 43% of Self-Directed Ps. Across all time points, the rate of maintaining daily SW practices was 1.43 times higher in Guided than in Self-Directed group (95% CI: 1.20-1.70, $P < 0.0001$).
Steinberg, et al., 2013 (52); Steinberg, et al., 2014 (53)	2-group, 6-mo intervention for WL, further 3-mo follow-up. Int group: daily SW, web-based WL graph, and weekly e-mails with tailored feedback and lessons vs. a delayed intervention Con.	$N = 91$; Int ($n = 47$): 70.2% female, 70.2% White, age 43.0 ± 11.4, BMI 33.3 ± 4.0, retention 95.7%; Con ($n = 44$): 79.5% female, 71.5% White, age 44.7 ± 10.6, BMI 31.5 ± 3.1, retention 95.5%.	The 6-mo intervention consisted of 4 main components: (1) cellular-connected "smart" scales for daily SW; (2) web-based graph of weight trends over time; (3) weekly tailored feedback via e-mail on SW frequency and WL progress; and (4) 22 weekly lessons on behavioral weight control via e-mail. Int Ps were instructed to SW daily at the same time each day using the smart scales. Con group received no intervention during the study period.	Electronic recorded: The smart scale displayed current weight and sent it directly to a website (www.bodytrace.com) via the wireless cellular network. The scales did not rely on an individual's cell service, but rather were connected to the Bodytrace website via a separate cell service embedded in the scales. This allowed Ps to use the scales in any location that had cell service.	Over the 6-mo study period, Int group SW on average more days per week compared to Con (6.1 ± 1.1 vs. 1.1 ± 1.5; $P < 0.0001$). Int group on average had more WL compared to delayed Con group at 6 mo [−6.55% (−7.7, −5.4) vs. −0.35% (−1.5, .79); group × time interaction: $P < 0.001$]. At 6 mo, there was a significant group × time interaction for body dissatisfaction ($P = 0.007$) and dietary restraint ($P = 0.001$), with Int group reporting lower body dissatisfaction and greater dietary restraint compared to controls.

TABLE 1. (continued).

Authors	Study aims/design	Sample/retention	Intervention	SW measurement	Outcomes related to SW
Madigan et al., 2013 (54)	2-group, 3-mo intervention, 9-mo follow-up, total 12-mo study for WM. Int (weekly SW) vs. Con.	$N = 3768$; Int ($n = 3290$): 86.7% female, 83.9% White, Age 49.9 ± 14.9, BMI 35.1 ± 5.7, retention 81%; Con ($n = 478$): 68.0% female, 86.7% White, age 51.1 ± 14.7, BMI 33.7 ± 3.6, retention 79%.	Int group received 2 telephone calls, the offer of free weighing scales, and encouragement to SW weekly and record this on a card. The main aim of intervention components was to encourage and facilitate regular SW. Con: no weight maintenance intervention.	Self-report: recording card.	Int: group on average regained 1.23 ± 5.8 kg, whereas the Con group regained 1.83-5.5 kg. Adjusting for covariates resulted in a mean difference of 0.68 kg (95% CI: 0.12-1.24) at 12-mo follow-up.

Note: SW: self-weigh; WC: weight change; WL: weight loss; WM: weight maintenance; WG: weight gain; yr: year; mo: month; wk: week; Ps: participants; Int: intervention; Con: control; BMI: body mass index; SBT: standard behavioral treatment for weight loss; Tx, treatment; NA: not available.
The unit of BMI: kg/m^2; the unit of age: years.

17 studies, 15 were conducted in the United States; the other two studies were conducted in the United Kingdom (43,54). The sample sizes varied from 32 to 3768 and included a high precent of female participants (61-100%) and 62-91% Whites. Average body mass index (BMI) ranged from 28 to 40 kg m^{-2}; however, one study reported only baseline weight (56). Overall, the length of the studies ranged from 16 weeks to 3 years: 10 ranged from 6 weeks to 12 months (27,43,44,48,49,52,54,56,57,59), five lasted between 18 (37,45) and 24 months (41,51,58), one was 30 months (47), and one 3 years (55). Eight studies followed participants beyond the intervention period (43,44,47,49,52,54,58,59). Retention rates varied from 13 to 96%, with 10 studies retaining >80% of participants (37,44,47,49,51,52,54,57-59), five retaining 60-80% (27,41,48,55,56) and two retaining less than 60% (43,45).

Most studies included self-weighing as part of an extensive multicomponent intervention, but only two tested a self-weighing intervention where the effects of regular self-weighing were isolated in terms of intervention delivery (54,56). One study compared differences in weight gain among freshmen college students (≥18 years old) with and without daily weighing in the first academic semester (56), while another study examined the effect of weekly weighing on preventing weight regain among those who had recently lost weight (54). Among the remaining 15 studies, one 18-month clinical trial reported only 6-month (46) and 12-month (45) results due to low retention while two other studies analyzed only the experimental arm that used self-weighing (47,49).

Nine studies provided the treatment group participants with a home digital scale and instructions to weigh at a specified interval (37,44,45,48,52,54,56-58); the other eight studies provided intervention groups with self-weighing instructions supplemented with a behavioral weight control intervention. In two studies, participants in the intervention and control groups received similar self-weighing instructions (27,59). Four studies provided feedback to the treatment group on behavioral changes based on self-weighing results (36,44,52,59). Wing and colleagues instructed participants to use problem solving skills to regulate weight, using a weight-monitoring system based on color zones (36,44,59).

Assessment methods

Three approaches were used to assess the habit of self-weighing in the 17 studies reviewed. Only three studies used scales that transmitted the weight data remotely to the research center or stored the data for later uploading of the data (44,45,52). The remaining 14 studies used self-reported methods and asked the participants about their habit of self-weighing. Nine of these studies used a single question asking about frequency of self-weighing with response options being never, about once a year or less, every other month, once a month, once a week, once a day, or more than once a day (27,41,48,49,51,55,57-59). Wing and colleagues asked participants to indicate how frequently they weighed themselves during the past month using a 7-point scale ranging from several times a day to never (37). The remaining studies used e-mail (56), a daily monitoring form (43), recording card (54), postcards (44), or website weight tracking (47).

Adherence to self-weighing

All but five of the 17 studies reported adherence to self-weighing (44,48,51,52,59). Gokee-Larose et al. reported that ~90% of the participants weighed themselves daily at the end of the 10-week

TABLE 2 Studies on weight gain prevention

Authors	Study aims/design	Sample/retention	Intervention	SW measurement	Outcomes related to SW
Jeffery et al., 1999 (35,55)	3-group, 3-yr study with 3 conditions: an educational intervention, the educational intervention plus a lottery incentive for returning monthly self-monitoring postcards, or a minimal contact control Con.	$N = 809$; 81% female; 87% White; age 34.5 ± 6.5; BMI 27.2 ± 5.9; retention 72%.	Int: educational intervention + SW (does not mention if giving Ps scale at home); weighing instructions stated, "Weighing yourself is an excellent monitoring activity. … Weigh yourself at least once a week." Con: minimal contact.	Self-reported by answering question "How frequently do you weigh yourself?"	Daily SW was associated with WL at 12 and 24 mo; all other weighing categories were associated with WG.
Levitsky et al., 2006 (56) (Study 1, Fall 2002)	2-group study examining effects of SW on WG prevention from beginning to the end of the semester.	$N = 32$; 100% female; race not reported; age ≥ 18; weight 62.5 ± 10.2 kg; retention 68.8% Int, 93.8% Con.	All were given basic nutritional information. Int: Ps received analog bathroom scale and were instructed to SW. Ps e-mailed their daily weight to staff. Con: no SW.	Self-reported by e-mail.	Ps in daily SW group gained 0.1 ± 0.99 kg, while Ps without daily SW gained 3.1 ± 0.51 kg ($P = 0.001$).
Levitsky et al., 2006 (56) (Study 2, Fall 2003)	2-group study examining effects of SW on WG prevention from beginning to the end of the semester.	$N = 41$; 100% female; age ≥ 18; weight 62.0 ± 8.6 kg; retention 94.1% Int, 66.7% Con.	All were given basic nutritional information. Int: Ps received an analog scale and SW. Ps e-mailed their daily weight to staff and received linear line of 7 days weight data. Con: no SW.	Self-reported by e-mail.	Int group lost 0.82 ± 0.56 kg, whereas Con group gained 2.0 ± 0.65 kg ($P < 0.01$).
French et al., 2011 (57)	2-group, 12-mo study; households (HHs) randomized to intervention or Con.	$N = 90$; 93% female; 79% White; age 41; BMI 29.6; retention 96%.	Int: behavioral treatment + SW; each Int HH was given a home digital scale and was instructed to daily SW for adults. Con: group assignment.	Self-reported.	Adults in Int HHs ↑ frequency of SW compared with adults in Con HHs. At follow-up, 71% of adults in Int HHs SW ≥ weekly, compared to 36% of adults in Con. No significant HH differences were observed by treatment group for change in BMI.
VanWormer et al., 2012 (58)	24-mo, 2-group study. 3 work sites received a WG prevention intervention, and 3 others received no treatment.	$N = 1747$; 61% female; 88% White; age 44.2 ± 10.3; BMI: ≥ 30.0 (33%); 25.0-29.9 (36%); <25.0 (31%); retention 81%.	Int: work environment changes + SW. 4 balance beam scales were placed at various locations in work site buildings that were easily accessible and frequently used. Con: no treatment.	Self-reported by answering question "How often do you weigh yourself?"	55% ≤ monthly, 28% weekly, 17% ≥ daily SW. Ps who SW daily and weekly lost about 1.8 kg and 0.9 kg, which was more than Ps who SW monthly. Greatest WL was Ps who were obese at baseline and SW daily at 24 mo (-4.4 ± 0.8 kg). Largest WG was Ps who were at a healthy BMI at baseline and SW monthly at 24 mo (2.1 ± 0.4 kg).
Gokee-LaRose et al., 2010 (59)	16-wk study with 8-wk treatment, 8-wk follow-up and 2 groups: Small Changes (SC) and Large Changes (LC).	$N = 52$; 98% female; 68.2% White; age 25.6 ± 4.7; BMI 26.7 ± 2.4; retention 84.6%.	All Ps were taught to SW daily combined with behavioral weight control treatment, but with different goals and prescriptions.	Self-reported.	Majority of Ps SW daily (91% in LC and 100% in SC at 8 wk, $P = 0.16$; and 61% in LC and 90% in SC at 16 wk, $P < 0.05$). WC over the intervention was significantly different between groups. Daily SW was perceived positively in both groups at 8 wk with no group differences.

Note: SW: self-weigh; WC: weight change; WL: weight loss; WM: weight maintenance; WG: weight gain; yr: year; mo: month; wk: week; Ps: participants; Int: intervention; Con: control; BMI: body mass index. The unit of BMI: kg m^{-2}; the unit of age: years.

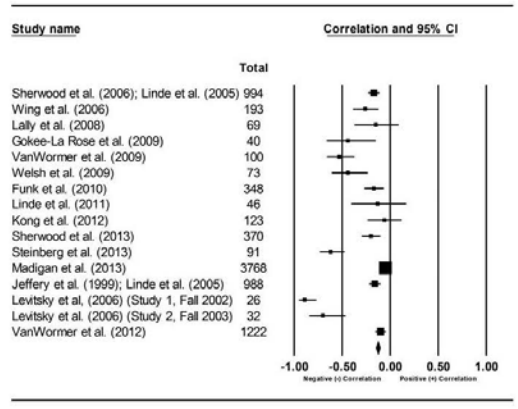

Figure 2 Forest plot for the correlations between frequency of self-weighing and weight loss.

intervention, which decreased significantly at the 20-week follow-up (44). This pattern of initial high level of adherence to self-weighing followed by a gradual decrease was reported by others (48,52). Another study by the same investigators showed that the majority of participants weighed daily at 8 weeks in two treatment conditions (91% vs. 100%), then decreased at 16 weeks (61% vs. 90%) (59). Sherwood et al. reported that overall participants weighed themselves daily 54% of the days but did not report the pattern of self-weighing over time (51).

The effect of self-weighing on weight change

All of the 17 studies reviewed reported that more frequent self-weighing was associated with greater weight loss (27,43-45,48,49,52), less weight regain (36,41,47,51,54) and better weight gain prevention (55-59). However, the effect sizes varied across the studies (Figure 2). Also, the frequency of self-weighing varied greatly in these studies. Specifically, five studies reported that daily weighing was associated with better outcomes (27,37,44,49,52). Two studies demonstrated that weekly weighing was associated with better weight loss (45) and weight maintenance (54). Vanwormer et al. (2012) showed that participants lost more weight with daily and weekly weighing than monthly weighing (58), while Lally et al. reported no differences between weekly and monthly weighing (43).

The effect of self-weighing on psychological effects

Five studies reported an association between self-weighing and psychological outcomes. Investigators found no evidence that there were adverse effects to frequent self-weighing (27,37,44,49,53). Rather, an increase in self-weighing was associated with an increase in dietary restraint and body satisfaction, a decrease in disinhibition, depressive symptoms, as well as weight and shape concerns (27,37,44,49,53). Also, two studies investigated the participants' perceptions about daily self-weighing via an eight-point Likert-scale (1 = not satisfied to 8 = very satisfied) at the end of the program (52,59). The results showed that daily self-weighing was perceived positively, easy to do, easy to remember, and helpful.

Discussion

This systematic review synthesized the evidence of longitudinal associations between self-weighing and weight change. Based on the 17 reviewed articles, regular self-weighing was associated with successful weight loss, weight maintenance, and weight gain prevention in adults seeking behavioral weight loss treatment. The results also suggested that there were no negative psychological effects of frequent self-weighing.

One methodological weakness of the reported studies was how self-weighing was assessed. Most of the studies used self-reported methods and asked the participants about the frequency of self-weighing (e.g., daily, weekly), which might not accurately reflect their actual weighing behavior. VanWormer et al. (2008) conducted a literature review on self-weighing and suggested more objective means of assessing self-weighing frequency, such as electronic scales, were needed to validate self-reported measures (38). However, since that review in 2008, only three studies have reported using electronic scales to objectively measure self-weighing behaviors. These investigators used scales that transmitted the weight data remotely to the research center (45,52) or stored the data for later uploading of the data (44). The main advantage of these electronic scales is to provide an objective measure of self-weighing frequency. The main disadvantage is the potential technical issues affecting reliance on cellular service. However, such problems occurred only in a small number of participants, and they were able to find alternative places with cellular service to weigh (e.g., work) (52). Other current technologies also permit real-time transmission of self-weighing data. For example, WiFi and Bluetooth enabled scales are available that can transmit the weight data in real time to a self-monitoring server that may display the graphical data for the participant (60). A disadvantage to the WiFi scale is that if the person moves the scale to another location, the data can be stored in the device but not transmitted to the server until back in the WiFi network that the scale set up to connect; however, the blue tooth enabled scales can be used in any setting and thus permit a person to move the scale when traveling and still transmit the data in real time.

Although five studies reported short-term (<9 months) patterns of self-weighing with a gradual decline over time, no studies have reported the pattern of self-weighing over an extended time period (e.g., ≥12 months). Evidence has demonstrated that there is a gradual decline in adherence to self-monitoring of diet and exercise, which declines when the treatment sessions decrease in frequency (11). It is unknown if the pattern of adherence to self-weighing is similar to or differs from that of self-monitoring of diet and exercise in long-term weight loss intervention studies.

One question not answered in the literature is related to the frequency or dose of self-weighing required for successful outcomes. In 2008, VanWormer et al. suggested that weekly self-weighing seemed to be a reasonable strategy to endorse for adults (38). However, daily (27,37,44,49,52) or weekly (45,54,58) weighing were reported most often in our literature review. Although at this time, the evidence cannot not support endorsement of an ideal self-weighing frequency or duration for use of this strategy, the recent work provides more evidence that daily weighing is an acceptable strategy for weight loss intervention. With electronic scales becoming increasingly more common in weight loss treatment programs,

daily weighing seems more feasible as a strategy to regulate diet and exercise behavior changes. Moreover, daily weighing might be a useful strategy for weight maintenance after weight loss, since previous studies have found that reversing weight regain was rare but possible if individuals observed the weight regain early or addressed minor lapses (36,61).

Our review of the literature found consistent reports that there were no adverse psychological effects related to frequent self-weighing. Rather, an increase in frequency of self-weighing was associated with decreases in depressive symptoms, disinhibition, and body dissatisfaction. It should be noted that these studies concerned only treatment-seeking overweight or obese adults (27,37,44,49,53), as opposed to studies that focused on detecting overweight or obese from normal weight individuals (62), or managing weight among adolescents (63). Thus, self-weighing can be an effective and safe self-monitoring strategy that should be implemented in weight-control programs without concern for negative psychological consequences.

The major limitation of the reviewed studies was that the sample was composed of predominantly White, middle-aged females, resulting in homogeneity. This limited the generalizability of the findings and the understanding of the acceptability, adherence to, and effect of self-weighing among men and minority groups. This limitation also influenced the level of evidence and thus the conclusions and subsequent recommendations that can be made from this review. In contrast, this article had two main strengths: first, all the reviewed articles were based on longitudinal data; second, this is the first paper to our knowledge that reviewed the psychological effects of regular self-weighing among overweight and obese adults who are in weight loss intervention studies.

In conclusion, the findings provide evidence that regular self-weighing has been positively associated with weight loss and not with negative psychological outcomes. Future studies need to determine the optimal dose of self-weighing and also the effectiveness of self-weighing among subpopulations under-represented in weight loss studies. Moreover, future studies need to address factors influencing adherence to self-weighing protocols and how we can capitalize on the rapidly increasing use of in-home scales that transmit weight data remotely to support weight management. O

Acknowledgments

The author acknowledges the assistance from the authors who provided additional data for effect size calculations.

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any provision of this Agreement shall not operate or be construed as a waiver of or consent to any other or subsequent breach by such other party.

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APPENDIX C

QUESTIONS FOR FOCUS GROUP

Leader Guide for Conduct of Focus Group

Participants' Perspectives and Experiences of Daily Weighing

Leader: Hello! I would like to welcome each of you to our focus group session. My name is Rachel; I am a doctoral student in the School of Social Work. Thank you for agreeing to participate in this focus group. I am very interested in learning about your experience with using the electronic Scale over the last 12 months. The main purpose of our group today is to talk about your experiences of daily weighing while you were participating in the EMPOWER study. We will be using the information you give us to inform the development of strategies that support the use of this important self-monitoring intervention.

The group session will last around 90 minutes; the longest will be 90 minutes. We are eager to hear from each of you, even if you did not weigh yourself every day. The number of days that you actually weighed yourself is not important today. Rather, we are especially eager to hear about your actual EXPERIENCE of using the scale. What was it like for you? YOU are the experts in this, and we want to learn from you. There are no right or wrong answers. If any question causes you to feel uncomfortable, please feel free to 'pass' on the question. We do not want you to feel pressured in any way.

Before we begin, I want to make certain that you know we are recording the conversation today using two recorders to make sure that we are able to clearly hear each of you. When the recording has been transcribed, the content will be deleted. No names will be used in the transcription. The transcript file will be stored in a password-protected, secure computer in the School of Nursing at the University of Pittsburgh. I also want to review several ground rules that I ask you to observe during our discussion to ensure the comfort of all participants. First, I ask that you be respectful of one another by listening when others are speaking, and waiting until others are finished speaking before you begin. Second, please keep what is said in this room to yourself. Third, if you have a cell phone, please put it on vibrate and if you must take a call during the discussion, please step out of the room. If you need to use the restroom during the discussion, you will find it …...

I will be conducting the focus group today and xx is here to take notes. Are there any questions about what we are doing? Okay, let's start by introducing ourselves.

Questions:

1. Please tell me about your experience of daily weighing during the EMPOWER study.
    a. PROBE: what were you thinking? Feeling?
2. What made it easier for you to weigh yourself?
3. What made it difficult to weigh yourself every day? Do you think you would be able to manage these difficulties, and if so, what would you do?
4. Did daily weighing affect or influence your planned eating and physical activity? IF SO, how?
5. Do you still weigh yourself daily? If yes, what made you decide to do so? If no, what made you stop daily weighing?
6. Would you recommend self-weighing on a regular basis to a family member or friend? If so, how often would you recommend self-weighing? Daily, or less often? If you would not recommend daily weighing, please explain why.
7. What suggestions do you have for how best to use daily weighing in future weight loss programs?

Leader at the completion of the focus group: Thank you so much for taking time to meet with us today/this evening. We appreciate your sharing your knowledge and experiences with us. Others will benefit from what we have learned from you today.

APPENDIX D

CONSENT FORMS

D.1 CONSENT FORM 1

University of Pittsburgh

School of Nursing

3500 Victoria Street
Pittsburgh, Pennsylvania 15261
Fax: 412-624-2401

CONSENT TO ACT AS A PARTICIPANT IN A FOCUS GROUP STUDY

TITLE: Experiences of daily weighing during the 12-month weight loss program

PRINCIPAL INVESTIGATOR:

Yaguang Zheng, MSN
University of Pittsburgh
415 Victoria Building
Pittsburgh, PA 15261
Phone:412-320-9103
Email:yaz40@pitt.edu

SUPERVISOR & CO-INVESTIGATOR:

Lora E. Burke, PhD, MPH, RN
Professor
University of Pittsburgh
415 Victoria Building
Pittsburgh, PA 15261
Phone: 412-624-2305
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OTHER CO-INVESTIGATORS:

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Pittsburgh, PA 15260
Schweitzer Environmental Fellow
Email: rlw22@pitt.edu

Juliet M Mancino, MS, RDN, CDE
University of Pittsburgh
415 Victoria Building
Pittsburgh, PA 15261
Phone: 412-624-0966
Email: jmm197@pitt.edu

Why is this research study being done?
This study is being conducted to describe your perception and acceptance of daily weighing as well as perceived benefits and barriers to adherence to daily weighing.

Who is being asked to take part in this research study?
You are being invited to take part in this focus group because you completed the EMPOWER study, a 12-month weight loss study. During the EMPOWER study, you were instructed to use a Wi-Fi scale for daily weighing at home.

What are the procedures that will be performed for research purposes?
If you participate in this research, you will be asked to attend a focus group talking about your experience of weighing yourself daily. The focus group discussion will last appropriately 45 minutes. We may also want to include data contained in your research records from the EMPOWER study.

What are the possible risks, side effects and discomforts of this research study?
There are minimal risks associated with participating in this study. Maintaining confidentiality of the information is a very important concern, but a breach of confidentiality is a possible risk. You may also feel uncomfortable when discussing the personal topics during the focus group.

What are the possible benefits from taking part in this study?
You will most likely receive no direct benefit from taking part in this research study, but you could possibly learn more about the benefits of daily weighing. The results of the study will help us understand the acceptance of daily weighing and the perceived benefits and barriers of adherence to daily weighing, which will inform the development of an intervention to enhance adherence to this important behavior change strategy.

Who will know about my participation in this research study?
Any information about you obtained from this research will be kept as confidential (private) as possible. All documents related to your involvement in this research study will be stored in a either locked file cabinet or password-protected database. Your identity on the focus group data will be indicated by a study ID number rather than by your name. Documents that contain your name, such as your contact information and this consent form, will be stored separately. You will not be identified by name in any publication of research results unless you sign a separate form giving your permission (release). The digital file of the recorded interview will be deleted after the interview recording has been transcribed.

Will this research study involve the use or disclosure of my identifiable medical information?
We will not access your medical records for any reason.

Who will have access to identifiable information related to my participation in this research study?
Only the research team will have access to the identifiable data. In unusual cases, your research records may be released in response to an order from a court of law. It is also possible that

authorized representatives from the University of Pittsburgh Research Conduct and Compliance Office may review your data for the purpose of monitoring the conduct of this study. The data may be shared with others but it will be shared without identifiers.

For how long will the investigators be permitted to use and identifiable information related to my participation in this research study?
The investigators may continue to use, for the purposes described above, identifiable information related to your participation in this research study indefinitely, but for a minimum of 7 years past study completion.

Is my participation in this study voluntary?
Your participation in this research study is completely voluntary. Whether or not you provide your consent for participation in this research study will have no effect on your current or future relationship with the University of Pittsburgh. Whether or not you provide your consent for participation in this research study will have no effect on your current or future medical care at a UPMC hospital or affiliated health care provider or your current or future relationship with a health care insurance provider. Whether or not you participate, or choose to withdraw from this study will not affect your standing/relationship with the EMPOWER study.

May I withdraw, at a future date, my consent for participation in this research study?
You may withdraw, at any time, your consent for participation in this research study. Any identifiable research information recorded for, or resulting from, your participation in this research study prior to the date that you formally withdrew your consent may continue to be used and disclosed by the investigators for the purposes described above.

Will I be paid if I take part in this research study?
You will be compensated $25 for participation in the focus group discussion and $5 for parking or transportation. Food and drink will be available at the time.

Are there any costs to me or my insurance carrier if I participate in this study?
You will not be charged for any of the research activities that are associated with this study.

****

VOLUNTARY CONSENT

All of the above has been explained to me and all of my current questions have been answered. I understand that I am encouraged to ask questions about any aspect of this research study during the course of this study, and that such future questions will be answered by the researchers listed on the first page of this form.

Any questions I have about my rights as a research participant will be answered by the Human Subject Protection Advocate of the IRB Office, University of Pittsburgh (1-866-212-2668).

By signing this form, I agree to participate in this research study. A copy of this consent form will be given to me.

Participant's Signature	Date

Participant's Printed Name

CERTIFICATION of INFORMED CONSENT

I certify that I have explained the nature and purpose of this research study to the above-named individual(s), and I have discussed the potential benefits and possible risks of study participation. Any questions the individual(s) have about this study have been answered, and we will always be available to address future questions as they arise. I further certify that no research component of this protocol was begun until after this consent form was signed.

Printed Name of Person Obtaining Consent	Role in Research Study
Signature of Person Obtaining Consent	Date

D.2 CONSENT FORM 2

University of Pittsburgh

School of Nursing

3500 Victoria Street
Pittsburgh, Pennsylvania 15261
Fax: 412-624-2401

CONSENT TO ACT AS A PARTICIPANT IN A FOCUS GROUP STUDY

TITLE: Experiences of daily weighing during the 12-month weight loss program

PRINCIPAL INVESTIGATOR:

Yaguang Zheng, MSN
University of Pittsburgh
415 Victoria Building
Pittsburgh, PA 15261
Phone:412-320-9103
Email:yaz40@pitt.edu

SUPERVISOR & CO-INVESTIGATOR:

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Juliet M Mancino, MS, RDN, CDE
University of Pittsburgh
415 Victoria Building
Pittsburgh, PA 15261
Phone: 412-624-0966
Email: jmm197@pitt.edu

Why is this research study being done?
This study is being conducted to describe your perception and acceptance of daily weighing as well as perceived benefits and barriers to adherence to daily weighing.

Who is being asked to take part in this research study?
You are being invited to take part in this focus group because you completed the EMPOWER study, a 12-month weight loss study. During the EMPOWER study, you were instructed to use a Wi-Fi scale for daily weighing at home.

What are the procedures that will be performed for research purposes?
If you participate in this research, you will be asked to attend a focus group talking about your experience of weighing yourself daily. The focus group discussion will last appropriately 45 minutes. We may also want to include data contained in your research records from the EMPOWER study.

What are the possible risks, side effects and discomforts of this research study?
There are minimal risks associated with participating in this study. Maintaining confidentiality of the information is a very important concern, but a breach of confidentiality is a possible risk. You may also feel uncomfortable when discussing the personal topics during the focus group.

What are the possible benefits from taking part in this study?
You will most likely receive no direct benefit from taking part in this research study, but you could possibly learn more about the benefits of daily weighing. The results of the study will help us understand the acceptance of daily weighing and the perceived benefits and barriers of adherence to daily weighing, which will inform the development of an intervention to enhance adherence to this important behavior change strategy.

Who will know about my participation in this research study?
Any information about you obtained from this research will be kept as confidential (private) as possible. All documents related to your involvement in this research study will be stored in a either locked file cabinet or password-protected database. Your identity on the focus group data will be indicated by a study ID number rather than by your name. Documents that contain your name, such as your contact information and this consent form, will be stored separately. You will not be identified by name in any publication of research results unless you sign a separate form giving your permission (release). The digital file of the recorded interview will be deleted after the interview recording has been transcribed.

Will this research study involve the use or disclosure of my identifiable medical information?
We will not access your medical records for any reason.

Who will have access to identifiable information related to my participation in this research study?
Only the research team will have access to the identifiable data. In unusual cases, your research records may be released in response to an order from a court of law. It is also possible that

authorized representatives from the University of Pittsburgh Research Conduct and Compliance Office may review your data for the purpose of monitoring the conduct of this study. The data may be shared with others but it will be shared without identifiers.

For how long will the investigators be permitted to use and identifiable information related to my participation in this research study?
The investigators may continue to use, for the purposes described above, identifiable information related to your participation in this research study indefinitely, but for a minimum of 7 years past study completion.

Is my participation in this study voluntary?
Your participation in this research study is completely voluntary. Whether or not you provide your consent for participation in this research study will have no effect on your current or future relationship with the University of Pittsburgh. Whether or not you provide your consent for participation in this research study will have no effect on your current or future medical care at a UPMC hospital or affiliated health care provider or your current or future relationship with a health care insurance provider. Whether or not you participate, or choose to withdraw from this study will not affect your standing/relationship with the EMPOWER study.

May I withdraw, at a future date, my consent for participation in this research study?
You may withdraw, at any time, your consent for participation in this research study. Any identifiable research information recorded for, or resulting from, your participation in this research study prior to the date that you formally withdrew your consent may continue to be used and disclosed by the investigators for the purposes described above.

Will I be paid if I take part in this research study?
You will be compensated $25 for participation in the focus group discussion and $5 for parking or transportation. Food and drink will be available at the time.

Are there any costs to me or my insurance carrier if I participate in this study?
You will not be charged for any of the research activities that are associated with this study.

****

VOLUNTARY CONSENT

All of the above has been explained to me and all of my current questions have been answered. I understand that I am encouraged to ask questions about any aspect of this research study during the course of this study, and that such future questions will be answered by the researchers listed on the first page of this form.

Any questions I have about my rights as a research participant will be answered by the Human Subject Protection Advocate of the IRB Office, University of Pittsburgh (1-866-212-2668).

By signing this form, I agree to participate in this research study. A copy of this consent form will be given to me.

Participant's Signature	Date

Participant's Printed Name

CERTIFICATION of INFORMED CONSENT

I certify that I have explained the nature and purpose of this research study to the above-named individual(s), and I have discussed the potential benefits and possible risks of study participation. Any questions the individual(s) have about this study have been answered, and we will always be available to address future questions as they arise. I further certify that no research component of this protocol was begun until after this consent form was signed.

Printed Name of Person Obtaining Consent	Role in Research Study
Signature of Person Obtaining Consent	Date

University Of Pittsburgh Institutional Review Board
Approval Date: 11/7/2013
Renewal Date: 11/6/2014
IRB #: PRO13090597

APPENDIX E

IRB APPROVAL LETTERS

E.1 IRB APPROVAL LETTER 1

University of Pittsburgh
Institutional Review Board

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

Memorandum

To: Yaguang Zheng
From: Sue Beers, PhD, Vice Chair
Date: 11/7/2013
IRB#: PRO13090597
Subject: Experiences of Daily Weighing during a 12-month Weight Loss Program

---

The University of Pittsburgh Institutional Review Board reviewed and approved the above referenced study by the expedited review procedure authorized under 45 CFR 46.110 and 21 CFR 56.110. Your research study was approved under:
45 CFR 46.110.(6)(7).

The risk level designation is Minimal Risk.

Approval Date: 11/7/2013
Expiration Date: 11/6/2014

For studies being conducted in UPMC facilities, no clinical activities can be undertaken by investigators until they have received approval from the UPMC Fiscal Review Office.

Please note that it is the investigator's responsibility to report to the IRB any unanticipated problems involving risks to subjects or others [see 45 CFR 46.103(b)(5) and 21 CFR 56.108(b)]. Refer to the IRB Policy and Procedure Manual regarding the reporting requirements for unanticipated problems which include, but are not limited to, adverse events. If you have any questions about this process, please contact the Adverse Events Coordinator at 412-383-1480.

The protocol and consent forms, along with a brief progress report must be resubmitted at least one month prior to the renewal date noted above as required by FWA00006790 (University of Pittsburgh), FWA00006735 (University of Pittsburgh Medical Center), FWA00000600 (Children's Hospital of Pittsburgh), FWA00003567 (Magee-Womens Health Corporation), FWA00003338 (University of Pittsburgh Medical Center Cancer Institute).

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

E.2 IRB APPROVAL LETTER 2

University of Pittsburgh
Institutional Review Board

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

Memorandum

To: Yaguang Zheng
From: Christopher Ryan, PhD, Vice Chair
Date: 3/4/2014
IRB#: MOD13090597-01 / PRO13090597
Subject: Experiences of Daily Weighing during a 12-month Weight Loss Program

The University of Pittsburgh Institutional Review Board reviewed and approved the requested modifications by expedited review procedure authorized under 45 CFR 46.110 and 21 CFR 56.110.

Modification Approval Date: 3/4/2014
Expiration Date: 11/6/2014

For studies being conducted in UPMC facilities, no clinical activities that are impacted by the modifications can be undertaken by investigators until they have received approval from the UPMC Fiscal Review Office.

Please note that it is the investigator's responsibility to report to the IRB any unanticipated problems involving risks to subjects or others [see 45 CFR 46.103(b)(5) and 21 CFR 56.108(b)]. Refer to the IRB Policy and Procedure Manual regarding the reporting requirements for unanticipated problems which include, but are not limited to, adverse events. If you have any questions about this process, please contact the Adverse Events Coordinator at 412-383-1480.

The protocol and consent forms, along with a brief progress report must be resubmitted at least one month prior to the renewal date noted above as required by FWA00006790 (University of Pittsburgh), FWA00006735 (University of Pittsburgh Medical Center), FWA00000600 (Children's Hospital of Pittsburgh), FWA00003567 (Magee-Womens Health Corporation), FWA00003338 (University of Pittsburgh Medical Center Cancer Institute).

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

E.3 IRB APPROVAL LETTER 3

University of Pittsburgh
Institutional Review Board

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

Memorandum

To: Yaguang Zheng
From: IRB Office
Date: 11/6/2014
IRB#: REN14090284 / PRO13090597
Subject: Experiences of Daily Weighing during a 12-month Weight Loss Program

Your renewal for the above referenced research study has received expedited review and approval from the Institutional Review Board under:

45 CFR 46.110.(6)
45 CFR 46.110.(7)

Please note the following information:

Approval Date: 11/6/2014
Expiration Date: 11/6/2017

This approval is for analysis of data only.

This study meets the criteria for an extended approval period of three years. In the event that any type of federal funding is obtained during this interval, a modification must be submitted immediately so the IRB can reassess the approval period.

Please note that it is the investigator's responsibility to report to the IRB any unanticipated problems involving risks to subjects or others [see 45 CFR 46.103(b)(5) and 21 CFR 56.108(b)]. Refer to the IRB Policy and Procedure Manual regarding the reporting requirements for unanticipated problems which include, but are not limited to, adverse events. If you have any questions about this process, please contact the Adverse Events Coordinator at 412-383-1480.

The protocol and consent forms, along with a brief progress report must be resubmitted at least **one month** prior to the renewal date noted above as required by FWA00006790 (University of Pittsburgh), FWA00006735 (University of Pittsburgh Medical Center), FWA00000600 (Children's Hospital of Pittsburgh), FWA00003567 (Magee-Womens Health Corporation), FWA00003338 (University of Pittsburgh Medical Center Cancer Institute).

Please be advised that your research study may be audited periodically by the University of Pittsburgh

Research Conduct and Compliance Office.

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