

Does Self-Weighing with Feedback Assist with the Self-Regulation of Energy Balance Behaviors?

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ABSTRACT

Self-monitoring of diet, physical activity, and/or weight is an important component of the behavioral treatment of obesity. Self-weighing with feedback, in which the feedback is aligned with action of self-weighing, appears to enhance weight management. However, the frequency of self-monitoring with feedback has yet to be examined thoroughly in experimental settings, and it is unclear what diet and/or physical activity behaviors occur following self-weighing with feedback. This study randomly assigned 22 young adults seeking to maintain their weight to one of three conditions: daily weighing with feedback, weekly weighing with feedback, or no weighing control. Participants in the daily and weekly weighing groups were provided with Bluetooth scales and instructed to weigh themselves one time per day or one time per week, respectively, for four weeks. Participants received feedback either daily (daily weighing group) or weekly (weekly weighing group) on their change in weight and a suggestion of how to increase or decrease their energy balance by 150 calories in order to maintain their current weight. Diet, physical activity, weight, self-esteem, mood, eating attitudes, and unhealthy weight control behaviors were measured at baseline and follow-up. Participants in the weighing groups gained significantly less weight ($-1.4 \text{ lbs} \pm 3.0$) than the no weighing control group ($2.8 \text{ lbs} \pm 3.3$). Weight changes were $-0.4 \text{ lbs} \pm 1.1$ for the daily weighing group, $-2.4 \text{ lbs} \pm 4.0$ for the weekly weighing group, and $2.8 \text{ lbs} \pm 3.3$ for the no weighing group, and post-hoc comparisons showed that the weight change in the weekly weighing group was significantly less than the no weighing control. Analyses of covariance showed no significant differences in energy intake or physical activity behaviors between groups at follow-up. No harmful effects of self-weighing with feedback were detected. Results suggest that self-weighing with feedback has no harmful effects and may be useful for weight control, especially weekly weighing with feedback, among adults of a healthy weight seeking to maintain their weight.

TABLE OF CONTENTS

Chapter I: Literature Review	1
Background and Significance	1
Self-Monitoring.....	2
Self-Regulation Theory.....	5
<i>Self-Observation</i>	5
<i>Judgement Process</i>	6
<i>Self-Reaction</i>	6
Self-Monitoring of Weight as an Intervention for Weight Management	7
Occurrence of Self-Regulation in Self-Weighing Intervention	12
Potential Consequences of Self-Weighing.....	13
Conclusion	14
Specific Aims	15
 Chapter II: Manuscript.....	 16
Background	16
Study Design	19
Methods.....	19
Participants and Recruitment	19
Procedures.....	20
<i>Baseline Assessment</i>	20
<i>Self-Weighing Conditions</i>	21
<i>Follow-Up Assessment</i>	23
Measures	24
<i>Anthropometrics</i>	24
<i>Demographics</i>	24
<i>Behaviors</i>	25
<i>Unintended Negative Consequences</i>	26
<i>Follow-Up Questionnaire</i>	28
<i>Process Evaluation</i>	29
Statistical Analysis.....	29
Results	30
Participant Characteristics	30
Specific Aim 1	35
Specific Aim 2	38
Secondary Outcomes of Interest	43
<i>Eating Attitudes, Binge Eating, Unhealthy Weight Control Behaviors</i>	43
<i>Mood and Self-Esteem</i>	43
Follow-Up Questionnaire.....	44
Process Evaluation	45
Discussion.....	46
Conclusion	49

References	51
Appendices	56
Appendix A – Participant Timeline.....	57
Appendix B – ASA24 Instructions.....	58
Appendix C – Armband Instructions.....	59
Appendix D – Nutrition Information	60
Appendix E – Yunmai SE Scale Instructions	61
Appendix F – 150 Calorie Statements	62
Appendix G – Demographic Questionnaire	64
Appendix H – EAT-26	66
Appendix I – BES.....	68
Appendix J – Unhealthy Weight Control Behaviors	72
Appendix K – SSES	73
Appendix L – POMS.....	75
Vita	76

LIST OF TABLES

Table 1. Baseline characteristics of participants by weighing group.....	33
Table 2. Dietary and physical activity outcome measures of weighing group and no weighing control at follow-up day 1, day 2, and day 3	36
Table 3. Changes in secondary outcome measures from baseline to follow-up of weighing group and no weighing control.....	39
Table 4. Dietary and physical activity outcome measures of daily weighing group, weekly weighing group, and no weighing control at follow-up day 1, day 2, and day 3.....	40
Table 5. Changes in secondary outcome measures from baseline to follow-up of daily weighing group, weekly weighing group, and no weighing control	42

LIST OF FIGURES

Figure 1. Participant flow and retention into the Diet, Physical Activity, and Weight Trends Study	32
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LIST OF ATTACHMENTS

File 1	Appendix A – Participant Timeline.....	Appendix_A.docx
File 2	Appendix B – ASA24 Instructions.....	ASA24_instructions.pdf
File 3	Appendix C – Armband Instructions.....	Armband_instructions.pdf
File 4	Appendix D – Nutrition Information.....	Nutrition_handout.pdf
File 5	Appendix E – Yunmai SE Scale Instructions.....	Yunmai_instructions.pdf

Chapter I: Literature Review

Background and Significance

Over one-third of adults in the United States have obesity.¹ The high prevalence of obesity indicates a need for effective weight loss and weight-control strategies because less than 20% of adults with overweight and obesity who have successfully lost weight maintain a 10% reduction in body weight one year later.² According to the Evidence Analysis Library of the Academy of Nutrition and Dietetics, comprehensive weight management programs that include reduced calorie diets, increased physical activity, and behavior therapy strategies result in weight loss and weight maintenance among adults with overweight and obesity. There is strong evidence that behavior therapy strategies such as problem-solving, goal-setting, structured meal plans and meal replacements and portion control, motivational interviewing, and self-monitoring are effective in promoting weight loss and weight maintenance.³

Young adults are often cited as a population at risk for weight gain.⁴ Longitudinal cohort data from the National Longitudinal Study of Adolescent Health indicate that 12.7% of adolescents transitioning to young adulthood become obese, and 9.4% remain obese into adulthood.⁵ This time period of young adulthood from ages 18 to 25 years of age, often referred to “emerging adulthood,” is characterized by change and exploration. Young adults in this time period establish independence, self-identity, and responsibility.⁶ This is also a time when young adults establish health behavior patterns that will be carried into adulthood.⁷ With increasing numbers of young adults ages 18-24 years enrolled as postsecondary students,⁸ college is an important time to address weight-related behaviors and focus on health promotion.⁷ According to

The American College Health Association-National College Health Assessment (ACHA-NCHA), approximately 30% of college students have overweight or obesity.⁹ Weight gain during college has been attributed to lifestyle changes such as a more sedentary lifestyle, increased social drinking, altered sleeping patterns, and greater access to cafeteria and fast-food meals.¹⁰ ACHA-NCHA data indicate that only 8.5% of students consume the recommended 5 or more servings of fruits and vegetables per day, and 45.5% engage in vigorous exercise for at least 20 minutes or moderate exercise for at least 30 minutes on 3 or fewer days of the week.⁹ Therefore, finding strategies to assist young adults develop life-long skills to regulate energy balance through diet and physical activity could be beneficial.

Self-Monitoring

In the behavioral treatment of obesity, self-monitoring involves observing and recording behavior patterns such as diet, physical activity, and weight.¹¹ For diet and physical activity, this typically includes the use of hand-written or electronic food diaries and exercise logs.¹² Self-monitoring of weight involves tracking weight over time, which can also be done with written or electronic records. Self-monitoring allows individuals to be aware of and receive feedback on their current behaviors and make changes if behaviors do not align with their health goals, which include dietary, activity, and weight loss goals.¹³ Most behavioral weight loss interventions include weekly or bi-weekly meetings with a trained professional, either individually or in a group.¹⁴ A new weight management skill targeting changes in diet and/or physical activity is taught at each session. Because diet and physical activity are the primary determinants of an individual's weight, sessions begin with private measurements of weight so feedback about progress on diet, physical activity, and weight loss goals is provided. This regular feedback on

weight allows participants to see if their target diet and physical activity behaviors are improving, being maintained, or declining and then make changes to their behaviors based on this feedback.¹¹

A large body of research supports the notion that more frequent self-monitoring among adults with overweight and obesity is associated with weight loss¹⁵ and weight loss maintenance.^{16,17} A systematic review examined studies investigating the relationship between self-monitoring of diet and/or physical activity with weight loss.¹⁵ Fifteen studies focused on dietary self-monitoring through the use of paper or electronic diaries, and all 15 studies found significant associations between dietary self-monitoring and weight loss.¹⁵ Similar results were found among five studies using self-monitoring of physical activity for weight loss. Participants who consistently self-monitored their activity lost significantly more weight, exercised more frequently, and had fewer difficulties with exercising than those who did not self-monitor activity.¹⁵ Following weight loss, continued self-monitoring appears to be effective in maintaining weight.^{16,18} Among members in the National Weight Control Registry (NWCR), a registry of successful adult dieters who have lost at least 30 lbs. and have maintained that weight loss for at least one year, 50% reported the use of calorie counting to self-monitor their diet.¹⁶ A study by Peterson and colleagues¹⁸ aimed to further examine the contribution of dietary self-monitoring to weight loss maintenance. Following a 6-month behavioral weight loss program for women with overweight and obesity, participants were assigned to a 12-month extended care condition. Participants were instructed to self-monitor their diet at least three days each week using a paper food-record form, and they were also encouraged to adhere to the diet and physical activity recommendations provided during the initial weight loss program. Although completion

of the food records declined during the 12-month extended care condition overall, participants who sustained consistent, frequent monitoring of food intake maintained weight loss more effectively than those who did not monitor food intake as frequently or consistently.¹⁸

There is evidence to support that self-weighing, a marker of self-monitoring weight, is important for weight management. Seventy-one percent of women and 70% of men attempting to lose weight report frequently weighing oneself as a weight loss strategy,¹⁹ and among participants included in the NWCR, 36% reported daily weighing and 79% reported at least weekly weighing.²⁰ Individuals in the NWCR who reported decreases in self-weighing frequency after one-year gained significantly more weight and also reported increased fat intake, increased disinhibition, and decreased cognitive restraint.²⁰ Observational studies have consistently associated more frequent self-weighing with greater weight loss and weight loss maintenance among adults with overweight and obesity.²¹⁻²⁶

A randomized controlled trial that focused on the self-regulation of body weight for weight loss maintenance provides further evidence for the beneficial effects of frequent self-weighing.¹⁷ Wing and colleagues¹⁷ examined the efficacy of a self-regulatory program focused on daily weighing, delivered face-to-face or via the Internet, among adult men and women who had lost at least 10% of their body weight over the past two years. Participants (N = 314) were randomly assigned to a control group, face-to-face intervention group, or Internet intervention group. Participants in the intervention groups were given scales, asked to report their weight weekly, and taught to regulate their body weight while participants in the control group received informational newsletters about diet, exercise, and weight control. After 18 months, 72.4% of participants in the control group regained 2.3 kg or more compared to 54.8% of participants in

the internet intervention and 45.7% of participants in the face-to-face intervention. Participants in the intervention groups reported more frequent self-weighing than those in the control group, and fewer intervention participants who weighed themselves daily regained 2.3 kg or more compared to those who weighed themselves less often.¹⁷

Self-Regulation Theory

The use of self-monitoring as a behavioral strategy for weight management has a strong theoretical basis. Self-monitoring is founded on the self-regulation theory which proposes that self-evaluation of one's progress towards a goal is achieved through self-monitoring of some aspect of an individual's behavior.¹⁵ Albert Bandura, a well-known psychologist who first examined self-regulatory functions in the context of the Social Cognitive Theory, states that habit change is achieved through the development of self-regulatory skills and observation of one's behavior.²⁷ Bandura proposes that self-regulation process occurs in three stages: self-observation, judgement process, and self-reaction.²⁸

Self-Observation

If people do not pay attention to their behaviors, the environments in which they occur, and the effects produced by their behavior, people cannot change their actions. Therefore, successful self-regulation is dependent on consistent adherence to self-observation, also referred to as self-monitoring.²⁷ According to Bandura, self-monitoring serves two important functions in self-regulation. First, it provides information needed to set a realistic goal to work towards. Second, it allows the evaluation of one's progress towards a goal by providing feedback. Behavior change cannot be achieved if one does not receive feedback on their performance and progress toward a goal.²⁸

Judgement Process

Simply observing one's behavior does not provide adequate information to an individual to enact behavior change. Standards are needed for someone to compare their progress to and determine a course of action depending on how their performances measures up to some set standard.²⁸ People often compare their performance to the achievement of others, standardized norms, or past successes, and people are more motivated to change their behavior when they have set a certain goal.²⁷

Self-Reaction

Judging one's performance prepares an individual for self-reactive influence, the final component of the self-regulation theory. Self-regulatory control is achieved by creating rewards or incentives for one's self based on how their performance measures up when compared to the standard they have set for themselves. People pursue behaviors that produce positive self-reactions and result in rewards or incentives. These can be tangible self-rewards, such as making free time, taking a relaxing break, or engaging in recreational activities, or non-tangible rewards like increased self-respect and self-satisfaction.²⁸

One of the best demonstrations of the self-regulation theory in the context of health behaviors is the monitoring of blood glucose in type 1 diabetes patients. This takes the form of a negative feedback control system, or negative feedback loop,²⁹ which many of the main theories of self-regulation are based on.²⁸ This system motivates and regulates action through an error detector, via self-monitoring, that perceives a difference in an individual's performance and an individual's set standard or goal. A discrepancy between performance and goal prompts the individual to act to reduce the difference. If there is no discrepancy detected, the individual does

nothing.²⁸ For example, with individuals with type 1 diabetes, when blood glucose is self-measured (self-monitored), the value is then observed and compared to the blood glucose goal of treatment. If there is a difference between the measured level and the goal level, the individual engages in a controlling response or behavior to bring blood glucose to the goal level. This may involve injecting insulin if blood glucose is high or consuming a carbohydrate-rich source if blood glucose is low. Thus, blood glucose is regulated through external behaviors.²⁹

Self-Monitoring of Weight as an Intervention for Weight Management

Similar to how measuring blood glucose provides feedback about external behaviors that influence blood glucose, weight is an indicator of health that provides feedback about diet and physical activity behaviors that influence weight. Therefore, health professionals suggest that weight monitoring, or the monitoring of weight by the self (self-weighing) or others (e.g. medical doctor) using a scale, could be a simple, effective self-monitoring strategy for weight control (i.e., weight loss, weight loss maintenance, weight gain prevention).³⁰ The idea behind this strategy is that self-weighing provides the individual feedback to assess their progress and make changes to their diet and exercise habits when necessary.³¹ Because self-monitoring of food intake and physical activity can be difficult to maintain and adherence to these self-monitoring strategies has been shown to decrease over time, self-monitoring of weight could be a simpler strategy to adhere to long-term.^{18,32,33} This strategy could assist young adults with lifelong skills for achieving a healthy weight during this time period in which new behaviors are being learned.

However, as described previously, while greater self-weighing is related to better weight outcomes, these studies do not address if self-weighing alone can help with weight management.

Furthermore, if self-weighing alone is not enough to assist with weight management, these studies also do not assist with understanding what may need to be included with self-weighing to impact weight management, and/or how frequently self-weighing and feedback need to occur to develop self-regulation skills to enhance weight management.

Several randomized controlled trials have been conducted to ascertain what needs to be incorporated into a self-weighing intervention for successful weight management. One study isolated the effect self-weighing alone has on weight management.³⁴ First-year male and female university students (N = 116) were assigned to a daily weighing group, weekly weighing group, or no weighing control group for 12 weeks. The sample predominately consisted of individuals of a healthy weight. Participants randomized to the weighing groups were only provided with a personal analog scale and instructed to weigh themselves once a day (daily weighing group) or once a week on Sundays (weekly weighing group) upon rising from bed. No feedback about weight was provided. After 12 weeks, weighing had no significant effect on BMI change.³⁴ This suggests that self-weighing alone, with no other intervention components or feedback, does not help with weight management among young adults of a healthy weight.

The effect of self-weighing and weekly feedback on weight management was examined by Madigan and colleagues.³⁵ In a two-arm individually randomized trial, 183 adults with obesity were randomly assigned to an intervention or control group.³⁵ To isolate the effect of self-weighing while still blinding participants to the fact that the trial was about self-weighing, both groups were given a feasible yet ineffective weight loss intervention delivered in two, 45-minute sessions. The intervention group was provided scales and instructed to self-weigh daily. Intervention participants recorded their weights daily and then calculated their average weight

each week to compare to their target weight loss (i.e. weekly feedback). At baseline and a 3-month follow up, participants were weighed and measured, and completed questionnaires about weight management strategies³⁶ and physical activity (IPAQ-short).³⁷ After three months, the intervention group did not lose significantly more weight than the control group, and there was little evidence that self-weighing prompted the adoption of weight control strategies. This suggests that daily weighing with weekly feedback alone did not improve self-regulation or weight management.³⁵

The effect of weekly feedback alone, an intervention alone, and the combination of the two was examined in by a randomized controlled trial with first-year male and female college students.³⁸ The mean BMI of participants was 24.38 ± 5.05 kg/m², and the weight statuses of participants ranged from underweight (BMI = 17.52 kg/m²) to severely obese (BMI = 41.01 kg/m²).³⁸ Participants (N = 170) were randomized to a no treatment control group, feedback intervention group, Internet intervention group, or combined feedback and Internet intervention group. Participants in the feedback intervention group were asked to weigh themselves daily and report their weight weekly, and they received weekly graphic feedback on their change in weight and the corresponding caloric change. The Internet intervention consisted of six weekly sessions focused on environmental, personal, and behavioral factors involved in maintaining a healthy weight. Lastly, the combined feedback and Intervention group received the six-week online intervention described previously in addition to the weekly weight and caloric feedback from daily self-weighing. After controlling for the effect of baseline BMI, participants in the combined feedback and Internet intervention group who self-weighed daily and received weekly graphic feedback representing change in weight and calories in addition to participating in the

Internet intervention had significantly lower BMI scores compared to the no-treatment control group and Internet intervention group after the six-week intervention. Participants in the feedback intervention group who just participated in daily self-weighing with weekly graphic feedback and participants in the Internet intervention group did not differ significantly in BMI compared to the no-treatment control group after the 6-week intervention.³⁸ This suggests that daily weight monitoring combined with weekly feedback and a 6-week intervention was successful as preventing weight gain in a young adult college population. As found with Madigan and colleagues,³⁵ daily weighing with weekly feedback was not helpful for preventing weight gain.

However, a study by Levitsky and colleagues³⁹ demonstrated that daily self-weighing and daily feedback without an intervention can be effective in preventing college weight gain. Female college freshman students living on campus (N = 34) were randomly assigned to a control group or a daily-weighing treatment group for the first semester of college.³⁹ The initial mean weight of participants was 62.5 ± 10.2 kg, but weight status of participants was not reported. Both groups were given basic nutrition information on a healthy diet according to the Food Guide Pyramid and were instructed to eat three meals a day and avoid snacks. The treatment group was instructed to weigh themselves daily; they received daily feedback in the form of TMS, an algorithm used to estimate changes in body tissue mass from changes in daily body weight.³⁹ The change in weight was converted to calories. If the change in weight equaled at least 150 calories, feedback was provided to participants in the treatment group which included information on change in weight based on the slope derived from the TMS algorithm, what the change in weight was equivalent to in calories, and a piece of personalized diet and/or

physical activity advice on what a caloric deficit or excess would equal 150 calories (D.M. DellaValle, oral communication, February 2018). At the end of the semester, control participants gained an average of 2.0 kg compared to the self-weighing treatment group who lost an average of 0.82 kg, which was not statistically significant from zero.³⁹ These results suggest that daily self-weighing combined with daily weight feedback and personalized suggestions for maintaining energy balance may be an effective strategy for weight management.

According to the self-regulation theory, self-observation must occur followed by feedback. If feedback does not occur, people will not change their behavior because they cannot evaluate how their actions influence their performance.²⁸ Hence, both weekly and daily self-weighing without feedback did not appear to effectively aid in weight management.³⁴ When weekly feedback was given with daily weighing, there was still no evidence that this benefits weight management.^{35,38} This could indicate that more frequent feedback is needed to promote behavior change, or that feedback must be aligned with the act of self-monitoring to be effective. For example, even though daily self-monitoring was occurring in the studies by Madigan and colleagues³⁵ and Gow and colleagues,³⁸ feedback was provided weekly so it did not immediately follow self-observation of weight. When daily weighing was followed by daily feedback in the form of TMS, however, it demonstrated effectiveness for weight control.³⁹ It is unclear whether these same results would be observed when weekly weighing is aligned with weekly feedback. While this model would demonstrate the self-regulation theory because weekly weighing (self-monitoring) would be immediately followed by feedback, more frequent monitoring with feedback could be required to evoke a behavior response to influence weight.

Occurrence of Self-Regulation in Self-Weighing Intervention

According to the self-regulation theory, following the occurrence of self-monitoring, feedback, and evaluation of progress towards a goal, self-reaction should transpire. Self-reaction involves pursuing behaviors that contribute positively to one's progress towards a goal.²⁸ Thus, if self-weighing enhances weight management via self-regulation, feedback about weight that does not align with weight goals (i.e., weight loss, weight loss maintenance, or weight gain prevention) should produce changes in diet and/or physical activity to increase the likelihood of achieving weight goals. At this time, while the relationship between self-weighing and weight management has been examined, it is unclear what behaviors occur following feedback on self-weighing as little research has examined this. Steinberg and colleagues²⁵ did examine weight control behaviors among men and women with overweight, using The Weight Management Strategies Questionnaire (WSMQ)⁴⁰ and The Eating Behavior Inventory (EBI)⁴¹ in the WEIGH trial. Compared with those who weighed less than daily, a greater proportion of daily weighers reported the following weight control behaviors: reducing calorie intake by 500-1,000 calories each day, reducing between-meal snacks, reducing going out to eat, reducing the frequency or portion sizes of desserts, making daily small changes to physical activity, reducing time spent watching television, exercising for at least 30 minutes, removing high-calorie foods from home or work, and increasing daily steps.²⁵ Alternatively, Gow and colleagues³⁸ found no differences in their trial in dietary intake (assessed via food screener) and physical activity (assessed via a self-reported questionnaire) among first-year college students of all weight statuses that differed in self-weighing frequency and weight outcomes.³⁸

It is important to note that both of these investigations used very broad measures of dietary intake and self-reported measures of physical activity. Measures of diet using food screeners and self-report measures of physical activity will not provide an in-depth assessment to investigate how people respond to feedback on weight. Therefore, in-depth assessments of dietary intake and objective measures of physical activity are needed to fully capture how people regulate their diet and physical activity in response to self-monitoring of weight. Furthermore, these measures in the studies mentioned above were not collected in relation to the timing of self-weighing and occurrence of feedback.^{25,38} Because the self-weighing and feedback should prompt a self-reaction, to understand what reaction transpires measures need to be taken in line with the occurrence of self-monitoring and feedback.

Potential Consequences of Self-Weighing

There has been some speculation regarding negative psychological consequences of frequent self-weighing such as increased eating disorder cognitions and behaviors, decreased self-esteem, and increased depression and anxiety because self-weighing draws attention to the body and can emphasize discrepancies between an individual's current body shape and weight and desired shape and weight.³¹ Individuals with eating pathologies who experience severe weight and shape concerns commonly engage in frequent self-weighing (weighing more than one time per week) and have negative reactions as a result (i.e. increased shape concerns, weight concerns, and restraint).⁴²

However, among individuals free of eating pathology, there is not sufficient evidence from experimental research to conclude that frequent self-weighing results in negative psychological consequences,^{38,43-45} although correlational studies suggest some evidence of

this.^{30,46-48} A meta-analysis by Benn et al.⁴⁴ that examined the psychological impact of self-weighing found that randomized controlled trials typically reported a positive relationship between self-weighing and body-related attitudes while, in contrast, correlational studies typically reported a negative relationship.

Conclusion

Self-monitoring of diet, physical activity, and/or weight is an important component of the behavioral treatment of obesity. This is based on the self-regulation theory that states that behavior change results from self-observation of one's behavior followed by feedback, a judgement process in which one compares their performance to some set standard or goal, and finally a self-reaction in which one pursues behaviors that will move them towards a goal. Self-monitoring of weight through self-weighing appears to enhance weight management in behavioral interventions. Studies that have examined self-weighing in the absence of a behavioral intervention suggest that for self-weighing to be effective, feedback must be provided immediately following self-monitoring so feedback is aligned with the action of self-monitoring. While the frequency of self-monitoring with feedback has yet to be examined thoroughly in experimental settings, there is evidence that self-weighing with feedback even in the absence of a behavioral intervention appears to be effective. This could be especially beneficial to the young adult college populations where standard behavioral interventions appear to be less effective. Young adults in standard behavioral weight loss interventions have lower attendance, greater attrition rates, and poorer weight outcomes than older participants.⁴⁹ Furthermore, as young

adulthood is a time when health behavior patterns that will be carried into adulthood are being established,⁵⁰ understanding how self-weighing can assist in this process is important.

Lastly, according to the self-regulation theory, a change in behavior (i.e. self-reaction) should follow self-monitoring and feedback. However, little research has examined if this behavior change occurs, and studies that did have used broad measures of diet and self-reported physical activity that fail to capture changes in behavior. Furthermore, these measures were not collected in relation to the timing of self-weighing and feedback and, because self-weighing and feedback should prompt a self-reaction, measures need to be taken in line with the occurrence of self-weighing and feedback to understand what behavior change transpires as a result of self-monitoring.

Specific Aims

The purpose of this study is to examine if self-weighing with feedback, in which the feedback is matched to the timeframe of self-weighing, in the absence of a standard behavioral intervention assists with the self-regulation of energy balance behaviors among young adults. An additional question is does the frequency, daily or weekly, of the self-weighing with feedback influence self-regulation. The specific aims of this investigation are to determine: 1) if self-weighing with feedback provokes changes in diet and physical activity behaviors; and 2) if frequency of self-weighing and feedback influences changes in diet and physical activity behaviors. Furthermore, due to the persistent concerns that self-weighing may result in negative psychological consequences, this study also assessed secondary measures of disordered eating cognitions, unhealthy weight control behaviors, self-esteem, and mood.

Chapter II: Manuscript

Background

Self-monitoring of diet, physical activity, and/or weight is an important component of weight management.³ More frequent and consistent self-monitoring is associated with enhanced weight management.¹⁻⁵ It is believed that self-monitoring is helpful for weight management due to its potential role in self-regulation. Self-regulation theory states that behavior change results from corrective action that occurs following feedback about behavior. In this process one compares their performance to some set standard or goal, often via self-monitoring, and a reaction occurs in which one pursues behaviors that will move them towards a goal.^{27,28}

As self-regulation needs long-term information to assist with regulating behavior, this requires self-monitoring to occur for long periods. In the area of weight management, there is often poor long-term adherence to self-monitoring of diet and physical activity, but self-monitoring of weight, which provides feedback about diet and physical activity behaviors, through self-weighing may be easier to adhere to long-term.⁶⁻⁸ This could be especially beneficial to the young adult population who are often cited as a population at risk for weight gain.⁴ Furthermore, as young adulthood is a time when health behavior patterns that will be carried into adulthood are being established, identifying successful weight-control strategies is important.

There is evidence to support that self-weighing, a marker of self-monitoring weight, aids in weight control. Seventy-one percent of women and 70% of men attempting to lose weight report frequently weighing oneself as a weight loss strategy.¹⁹ Among participants included in the National Weight Control Registry (NWCR), a registry of successful dieters who have lost at least 30 lbs. and have maintained that weight loss for at least one year, 36% reported daily

weighing and 79% reported at least weekly weighing.²⁰ Individuals in the NWCR who reported decreases in self-weighing frequency after one-year gained significantly more weight and also reported increased fat intake, increased disinhibition, and decreased cognitive restraint.²⁰

Studies that have examined self-weighing in the absence of an intensive lifestyle intervention suggest that for self-weighing to be effective for weight control, feedback must be provided immediately following self-weighing so that feedback is aligned with the action of self-weighing.^{34,35,38} For example, when daily weighing is followed by daily feedback, there is evidence that this is effective for weight control.³⁹ However, when daily weighing was followed by weekly feedback, there was no evidence that this benefited weight management.^{35,38} This could indicate that more frequent feedback is needed to promote behavior change, or that feedback must be aligned with the act of self-monitoring to be effective.

If self-weighing enhances weight management via self-regulation, feedback about weight that does not align with weight goals (i.e., weight loss, weight loss maintenance, or weight gain prevention) should produce changes in diet and/or physical activity to increase the likelihood of achieving weight goals. While the relationship between self-weighing and weight management has been examined, it is unclear what diet and/or physical activity behaviors occur following feedback on self-weighing, as little research has examined this. Steinberg and colleagues²⁵ examined weight control behaviors, using The Weight Management Strategies Questionnaire (WSMQ)⁴⁰ and The Eating Behavior Inventory (EBI)⁴¹ in the WEIGH trial. Compared with those who weighed less than daily, a greater proportion of daily weighers reported the following weight control behaviors: reducing calorie intake by 500-1,000 calories each day, reducing between-meal snacks, reducing going out to eat, reducing the frequency or portion sizes of

desserts, making daily small changes to physical activity, reducing time spent watching television, exercising for at least 30 minutes, removing high-calorie foods from home or work, and increasing daily steps.²⁵ Alternatively, Gow and colleagues³⁸ found no differences in their trial in dietary intake (assessed via food screener) and physical activity (assessed via a self-reported questionnaire) in their groups that differed in self-weighing frequency and weight outcomes.³⁸

It is important to note that both of these investigations used very broad measures of dietary intake and self-reported measures of physical activity. Measures of diet using food screeners and self-report measures of physical activity do not provide in-depth assessments to investigate how people respond to feedback on weight. Furthermore, these measures were not collected in relation to the timing of self-weighing and feedback and, because self-weighing and feedback should prompt a self-reaction, behavioral measures need to be taken in line with the occurrence of self-weighing and feedback to understand what behavior change transpires as a result of self-monitoring.

To investigate if self-weighing with feedback, in which the feedback is matched to the timeframe of self-weighing, alters eating and activity behaviors and assists with the self-regulation of energy balance, and if frequency, daily or weekly of the self-weighing and feedback, influences self-regulation, the purpose of this study was to examine: 1) if self-weighing with feedback provokes changes in diet and physical activity behaviors; and 2) if frequency of self-weighing and feedback influences changes in diet and physical activity behaviors. Furthermore, due to the persistent concerns that self-weighing may result in negative

psychological consequences, this study also assessed secondary measures of disordered eating cognitions, unhealthy weight control behaviors, self-esteem, and mood.

Study Design

A 3x2 mixed factorial design was used with a between-subject factor of self-weighing group (daily weighing; weekly weighing; and no weighing control group) and within-subject factor of time (prior to self-weighing and feedback, and during self-weighing and feedback). The primary dependent variables were diet, physical activity, and weight. The secondary dependent variables used to measure potential adverse psychological effects were disordered eating cognitions, unhealthy weight control behaviors, self-esteem, and mood.

Methods

Participants and Recruitment

This study was advertised as a study investigating the eating habits, physical activity behaviors, and weight trends among young adults in which interested participants would have the opportunity to learn about their personal dietary and physical activity habits. Participants were recruited from June 2018 to January 2019. Flyers were posted and handed out around the University of Tennessee, Knoxville (UTK) campus, emails were sent via departmental and organizational electronic mailing lists, and announcements were made in introductory nutrition courses. Individuals who were interested in participating in the research study were asked to contact the Healthy Eating and Activity Laboratory (HEAL) for more information and were screened over the phone to determine initial eligibility. Eligibility for the study was based upon the following criteria:

Inclusion criteria:

1. Young adult between the ages of 18 and 29 years
2. Body Mass Index (BMI) between 19 kg/m² and 29.9 kg/m²
3. Weight goal to maintain current weight/prevent weight gain
4. Own an iPhone or Android to download the Yunmai app for weighing intervention
5. Has access to a computer with internet to complete dietary assessments online through ASA24
6. Present on campus for the time period required to complete the study

Exclusion criteria:

1. Self-reported previous or current diagnoses of an eating disorder, or at risk for an eating disorder defined as a score of ≥ 20 on the Eating Attitudes Test (EAT-26), and/or a score > 27 on the Binge Eating Scale (BES), and/or report of any extreme unhealthy weight control behaviors
2. Participating in another diet, weight loss, or physical activity program
3. Dietary or physical activity restrictions
4. Allergy to metal making participant unable to wear BodyMedia SenseWear Armband

After the phone screen, eligible participants were scheduled for a baseline assessment.

Procedures

Baseline Assessment

First, informed consent was obtained and height and weight were measured. Participants then completed a brief demographic questionnaire and questionnaires assessing eating attitudes (EAT-26), binge eating (BES), unhealthy weight control behaviors, self-esteem, and mood. Next,

eligible participants were provided login information for ASA24 and instructions on how to complete 24-hour recalls using ASA24 (see Appendix B).⁵¹ Throughout the next week, participants were randomly emailed on three days to complete three 24-hour recalls (1 weekend day, 2 weekdays). Participants were provided a SenseWear Armband and given instructions on how to use and care for the Armband (see Appendix C). Participants were instructed to wear the Armband for a minimum of 10 hours each day for the next week. At the conclusion of the session, participants were scheduled to return to HEAL one week later for a second appointment.

At the second appointment, the investigator confirmed that the participant successfully completed three 24-hour recalls through ASA24. Armband data was downloaded using SenseWear software to confirm that the participant successfully wore the Armband for at least 10 hours on the three days when the 24-hour recalls were completed. Participants who completed these baseline diet and physical activity measures were then randomized to the daily weighing group, weekly weighing group, or no weighing control group based on weight status (healthy weight or overweight). If participants did not complete all baseline measures, the participant's second appointment was rescheduled for one week later. Over the next week, participants were again asked to wear the Armband for a minimum of 10 hours each day and were randomly emailed on three days to complete three 24-hour recalls (1 weekend day, 2 weekdays).

Self-Weighing Conditions

Participants in all groups were provided with general nutrition information about how to build a healthy eating pattern based on the 2015-2020 Dietary Guidelines for Americans (see Appendix D).

Daily Weighing

Participants in the daily weighing group were given a Yunmai SE Weight Scale and instructions for its use (see Appendix E). Next, participants were given instructions to download the Yunmai mobile app and create a user profile. Participants were instructed to weigh themselves using the Yunmai SE Scale and app every day upon rising from bed (and before noon) in light clothing beginning in one week for four weeks. A reminder email and text message was sent to the participant to remind them to begin weighing on the assigned day. If on any day the participant had not weighed by 11am, the participant received a text reminder to weigh themselves.

After 2 weights had been collected (day 15), participants began to receive daily feedback on their change in weight and suggestions to maintain energy balance. They received an email with this feedback stating, “Your weight today is _____. Your weight has (increased/decreased) _____ pounds since yesterday.” If their weight increased, the email contained a message stating, “If your goal is to maintain your weight, you may consider decreasing your energy balance by 150 calories” and included one example of how to decrease their energy balance by 150 calories (see Appendix F). If participants’ weight decreased, the participants received a message in addition to their feedback on change in weight stating, “If your goal is to maintain your weight, you may consider increasing your energy balance by 150 calories” and included one example of how to increase energy balance by 150 calories (see Appendix F). Feedback messages were chosen based on the participant’s baseline dietary data collected through ASA24 and, therefore, tailored to each participant.

Weekly Weighing

Participants in the weekly weighing intervention group were given a Yunmai SE Weight Scale and instructions for its use. Next, participants were given instructions to download the Yunmai mobile app and create a user profile. Participants were instructed to weigh themselves using the Yunmai SE Scale and app one time each week upon rising from bed (and before noon) in light clothing beginning the following day for four weeks. A reminder text message was sent to the participant to remind them to begin weighing on the assigned day. If on a weekly weighing day the participant had not weighed by 11am, the participant received text reminder to weigh themselves.

After two weights had been collected (day 15), participants began to receive weekly feedback on their week and suggestions to maintain energy balance. Feedback and suggestions were provided as previously described above.

No Weighing Control

Participants in the non-weighing control group were asked to refrain from weighing themselves for the next four weeks.

At the conclusion of the session, participants were scheduled to return to HEAL three weeks later for their third session, and four weeks and one day later for their fourth and final session.

Follow-Up Assessment

At the third session, participants were given an Armband and instructed to wear the Armband for a minimum of 10 hours each day during for the next week and reminded on how to

complete 24-hour recalls using ASA24. Throughout the next week, participants were randomly emailed on three days to complete three 24-hour recalls (1 weekend day, 2 weekdays)..

At the fourth and final session, participants were weighed and measured and completed questionnaires for eating attitudes (EAT-26), binge eating (BES), unhealthy weight control behaviors, mood, and self-esteem. Participants in the weighing interventions also completed a qualitative follow-up questionnaire about their responses to weighing themselves and getting feedback on their weight. Participants returned the Armband and Yunmai SE Scale (intervention groups only) to the researcher. When all the measures were completed, participants were given a \$25 Walmart gift card. Participants were provided with an ASA24 Nutrition Report summarizing their average three-day baseline dietary intake, and two physical activity reports generated from SenseWear software summarizing their baseline and follow-up physical activity.

Measures

Anthropometrics

Height and weight were collected using a stadiometer and an electronic scale, respectively, at baseline and follow-up assessments. Standard procedures were used to collect the measurements.⁵² Participants were asked to remove their shoes, jackets, and any other items in their pockets. Body mass index (kg/m^2) was calculated from collected height and weight for each participant.

Demographics

Basic demographic information, such as gender, age, race, ethnicity, and education level, were collected via demographic questionnaire during the baseline assessment after informed

consent is obtained. Participants were asked to report their current frequency of self-weighing (see Appendix G).

Behaviors

For the self-regulation of weight, changes must be made to physical activity behaviors and/or eating behaviors. This study evaluated physical activity and diet to determine how participants engaged in self-regulation.

Physical Activity

Activity was collected with SenseWear Armbands worn by participants for at least 10 hours/day for one week at baseline and during the final week of the self-weighing condition. The SenseWear Armband utilizes a 2-axis accelerometer to detect motion, a heat flux sensor, galvanic skin response sensor (GSR), skin temperature sensor, and a near-body ambient temperature to calculate energy expenditure.⁵³ SenseWear Armbands have been shown to provide valid and reliable estimates of energy expenditure in free living conditions.⁵⁴⁻⁵⁶ The dependent variables derived from the SenseWear Armbands were total energy expenditure (kJ), moderate- to vigorous-intensity physical activity duration (3.0 METs and higher), and number of steps. Two participants ($n = 2$), both in the no weighing group, experienced SenseWear Armband equipment malfunctions when collecting follow-up physical activity data, so follow-up data was unable to be obtained.

Diet

Dietary intake data for 24-hour recalls were collected using the using the Automated Self-Administered 24-Hour (ASA24), Dietary Assessment Tool, version 2016, developed by the National Cancer Institute, Bethesda, MD.⁵⁷ The dependent variables collected from ASA24 were

total caloric intake, percent of total calories from carbohydrates, protein, and total fat, grams of dietary fiber, and total servings of fruits, vegetables, dairy, protein foods, and grains. Two participants ($n = 2$), one in the daily weighing group and one in the weekly weighing group, did not complete a third follow-up 24-hour recall using ASA24. For analyses, the average value of each dietary outcome variable was computed from follow-up recall day 1 and follow-up recall day 2 and used for the missing follow-up day 3 data.

Unintended Negative Consequences

There has been some speculation regarding negative psychological consequences of frequent self-weighing such as increased eating disorder cognitions and behaviors, decreased self-esteem, and increased depression and anxiety. Although correlational studies suggest some evidence of this,^{30,46-48} there is not sufficient evidence from experimental research to conclude that frequent self-weighing by healthy individuals results in negative psychological consequences.^{38,43-45} To evaluate possible unintended negative consequences, this study measured disordered eating cognitions, unhealthy weight control behaviors, self-esteem, and mood.

Eating Attitudes

The EAT-26⁵⁸ was administered to participants at baseline and follow-up assessments (see Appendix H). This 26-item self-report questionnaire is designed to measure symptoms and concerns that are characteristic of eating disorders. A high score (≥ 20) indicates concerns regarding body weight, body shape, and eating.⁵⁹ Participants scoring ≥ 20 during the baseline assessment were considered ineligible for the study and given information about UTK's Counseling Services. One participant ($n=1$) scored ≥ 20 on the EAT-26 at baseline and was

considered ineligible for the study and given information about UTK's counseling services. No participants ≥ 20 on EAT-26 at the follow-up assessment.

Binge Eating

The BES⁶⁰ was administered to participants at baseline and follow-up assessments (see Appendix I). This 16-item self-report questionnaire is designed to capture the behavioral, cognitive, and emotional features of binge eating that may be indicative of an eating disorder.⁶¹ A high score (>27) indicates severe binge eating problems.⁶² No participants scored >27 on the BES at the baseline assessment or follow-up assessment.

Unhealthy Weight-Control Behaviors

To assess the presence of extreme unhealthy weight control behaviors (UWCB), the following question was asked to participants at baseline and follow-up assessments: 'Have you done any of the following things in order to lose weight or keep from gaining weight during the past 4 weeks? (yes or no for each method).'⁶³ Behaviors categorized as less extreme UWCB included (1) fasted, (2) ate very little food, (3) used a food substitute (e.g. Slim-fast), (4) skipped meals and (5) smoked more cigarettes; and behaviors categorized as extreme UWCB included (6) took diet pills, (7) made yourself vomit, (8) used laxatives and (9) used diuretics (see Appendix J).⁵⁹ The number of UWCBs reported by the participant were summed at baseline and follow-up to produce scores ranging from 0-9 with a score of 0 indicating no UWCBs and higher numbers indicating more UWCBs. No participants reported the use of any extreme UWCBs at the baseline assessment or follow-up assessment.

Self-Esteem

Self-esteem was assessed at baseline and follow-up using the State Self Esteem Scale (SSES) (see Appendix K).⁶⁴ This is a 20-item scale that measures a participant's self-esteem at a given point in time. The 20 items are subdivided into 3 components of self-esteem: (1) performance self-esteem, social self-esteem, and appearance self-esteem. All items are answered using a 5-point scale (1= not at all, 2= a little bit, 3= somewhat, 4= very much, 5= extremely) with a higher score indicating greater self-esteem.

Mood

Mood was assessed at baseline and follow-up using the Profile of Mood States (POMS) (see Appendix L).⁶⁵ This is a 65-item questionnaire designed to evaluate individuals within seven different mood domains: fatigue-inertia, anger-hostility, vigor-activity, confusion- bewilderment, depression-dejection, tension-anxiety, and friendliness. The depression-dejection and tension-anxiety subscales were used for this study. The tension-anxiety subscale includes 9 items with scores ranging from 0-36, and the depression-depression includes 15 items with scores ranging from 0-60. Items are answered using a 5-point scale (0= not at all, 1= a little bit, 2= somewhat, 3= very much, 4= extremely) with a higher score indicating higher levels of anxiety and/or depression.

Follow-Up Questionnaire

To further evaluate participants' potential responses to self-weighing with feedback, participants in the daily and weekly weighing groups were asked the following open-ended questions at follow-up: 'If you saw your weight on the scale go up from the previous day/week, how did you respond?', 'If you saw your weight on the scale go down from the previous

day/week, how did you respond?', and 'If you saw your weight on the scale remain the same from the previous day/week, how did you respond?' Responses were analyzed using qualitative data analysis software NVivo; QSR International Pty Ltd. Version 12, 2018.

Responses for each question were coded for positive responses to self-weighing and feedback, negative responses to self-weighing with feedback, neutral responses to self-weighing with feedback, behavior change, and no behavior change. Next, data were analyzed for themes, and themes were compared between the daily weighing group and weekly weighing group.

Process Evaluation

To determine whether the self-weighing interventions were implemented as planned, this study evaluated participant's adherence to the self-weighing intervention.

Self-Weighing Frequency

To evaluate participants' adherence to the self-weighing intervention, self-weighing frequency was assessed using date and time-stamped weights recorded on the Yunmai mobile app for each intervention participant.

Statistical Analysis

The data were analyzed using SPSS version 24.0 for Mac (SPSS Inc., Chicago IL), with $\alpha \leq 0.05$. Baseline characteristics were compared between the groups with the use of the chi-square test for nominal data and analysis of variance for continuous data. Compliance to self-weighing frequency was examined between the daily and weekly self-weighing groups using an independent t-test. For specific aim 1, a 2x3 mixed analysis of covariance, with a between-subject factor of self-weighing group (weighing or no weighing) and within-subject factor of time (follow-up measure day 1, day 2, and day 3) was conducted for diet and physical activity

outcomes. There were significant differences between groups for age, baseline EAT-26 score, and enrollment in meal plan, so these were used as covariates in each analysis. For diet and physical activity outcomes, the mean baseline measure of the variable of interest was also used as a covariate in each analysis. For specific aim 2, similar analyses were conducted using a 3x3 mixed analyses of covariance, with a between-subject factor of self-weighing group (daily weighing, weekly weighing, and no weighing), a within subject factor of time (follow-up measure day 1, day 2, and day 3), and with identical covariates to what was described in the analyses for specific aim 2. Due to differences in baseline EAT-26 scores, for each secondary outcome, a change variable was calculated by subtracting the measure's value at baseline from the measure's value at follow-up. An analysis of covariance, with the independent variable as weighing group, dependent variable as the calculated change value, and covariates as the mean baseline measure of the variable of interest, baseline EAT-26 score, age, and enrollment in meal plan was conducted for weight, eating attitudes, binge eating, unhealthy weight control behaviors, mood, and self-esteem.

For significant outcomes ($p < 0.05$), post hoc pairwise comparisons using Bonferroni corrections were conducted to determine which groups differed in the outcome variables. The Greenhouse-Geisser corrections were used when appropriate for repeated measures to adjust for sphericity.

Results

Participant Characteristics

Participants were recruited between June 2018 and January 2019, and follow-up assessments were finished in February 2019. **Figure 1** presents the flowchart of the participants.

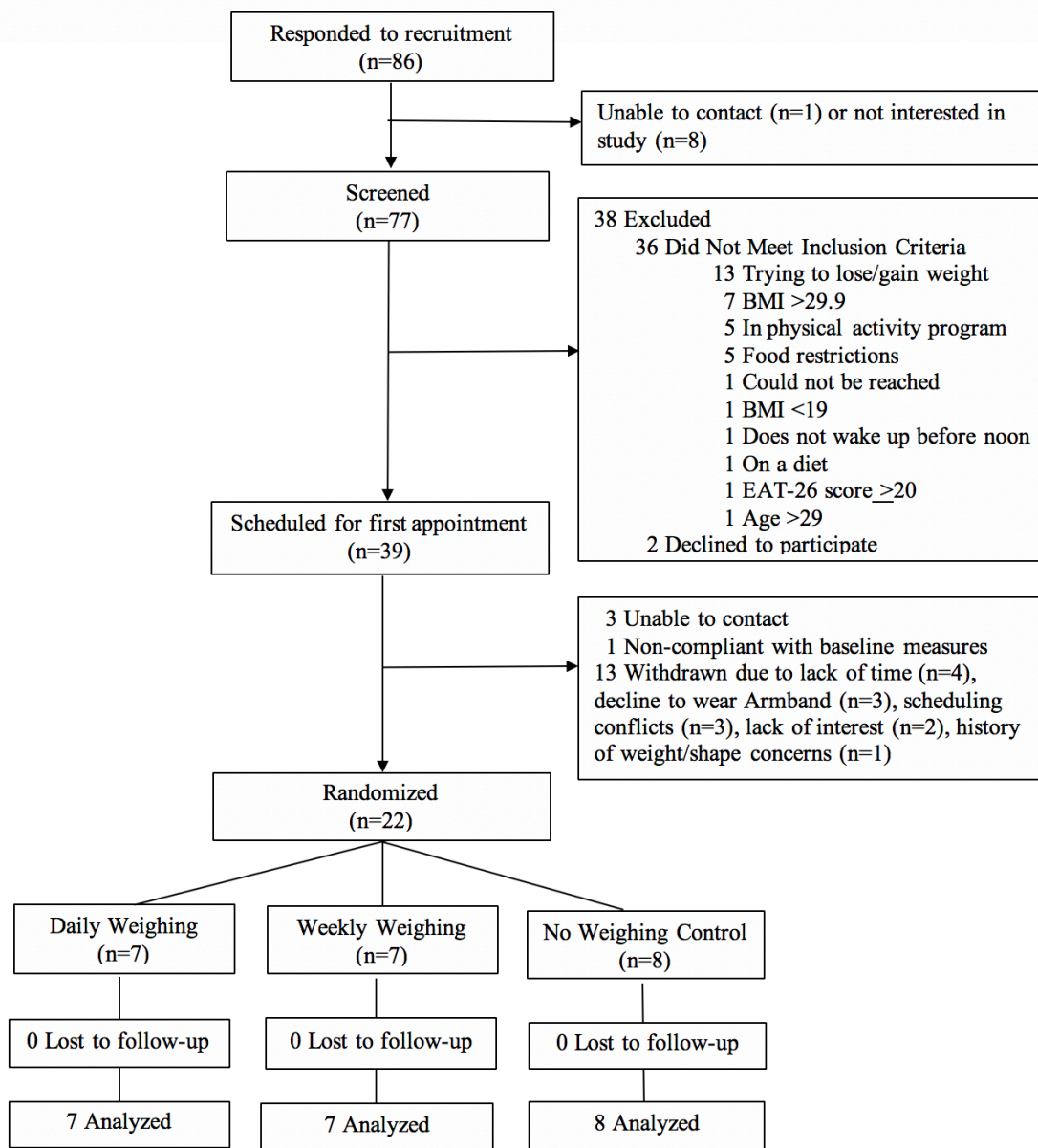


Figure 1. Participant flow and retention into the Diet, Physical Activity, and Weight Trends Study.

A total of 86 people responded to recruitment, and 77 were screened over the phone to determine initial eligibility. Thirty-nine eligible participants were scheduled for first appointments, and a total of 22 participants completed all measurements at baseline and were randomly assigned to daily weighing group, weekly weighing group, or control group. One hundred percent of the randomized participants completed follow-up assessments.

Table 1 displays the baseline characteristics of the 22 participants. Participants were 21.8 ± 3.13 years with a BMI of $23.1 \pm 2.3 \text{ kg/m}^2$. Participants were primarily female (81.8%), white (72.7%), single (77.3%), undergraduate students (59.1%), who were living off-campus (68.2%). Significant differences were observed between groups for age, $F(2,19) = 3.69, p = .044$. Post hoc contrasts revealed that the average age of participants in the weekly weighing group (23.6 ± 3.4 y) was significantly greater, $p = .045$, than the average age of participants in the daily weighing group (19.6 ± 1.3 y). However, age did not significantly differ between the daily weighing group and no weighing group ($p = .280$) or the weekly weighing group and no weighing group ($p = .989$). Significant differences were also observed between groups for enrollment in meal plan through the university, $X^2(2) = 6.73, p = .035$. A majority of participants in the daily weighing group were enrolled in a meal plan through the university (yes=85.7%; no=14.3%). In contrast, more participants in the weekly weighing group (yes=28.6%; no=71.4%) and no weighing group (yes=25%; no=75%) were not enrolled in a meal plan through the university.

Levene's test of homogeneity of variances showed that the variances for EAT-26 scores between groups were not equal, $F(2, 19) = 4.64, p = 0.026$. Therefore, a Kruskal-Wallis H test was conducted to examine the differences in baseline EAT-26 score between groups. Results indicated that the average EAT-26 score of participants in the weekly weighing group (1.9 ± 1.1)

Table 1. Baseline characteristics of participants by weighing group.

Characteristic	Total (n=22)	Daily Weighing (n=7)	Weekly Weighing (n=7)	No Weighing Control (n=8)
	← mean ± standard deviation →			
Age, y	21.8 ± 3.13	19.6 ± 1.3 ^a	23.6 ± 3.4 ^b	22.1 ± 3.1 ^{ab}
BMI at study entry, kg/m ²	23.1 ± 2.3	23.4 ± 2.3	23.1 ± 2.2	22.8 ± 2.8
	← n (%) →			
Weight status				
Healthy	18 (81.8)	5 (71.4)	6 (85.7)	7 (87.5)
Overweight	4 (18.2)	2 (28.6)	1 (14.3)	1 (12.5)
Gender				
Male	4 (18.2)	2 (28.6)	1 (14.3)	1 (12.5)
Female	18 (81.8)	5 (71.4)	6 (85.7)	7 (87.5)
Hispanic/Latino				
No	22 (100)	7 (100)	7 (100)	8 (100)
Race/ethnicity (could select multiple)				
American Indian or Alaskan Native	1 (4.5)	1 (12.5)	0 (0)	0 (0)
Asian	4 (18.2)	0 (0)	2 (28.6)	2 (25)
Black or African American	1 (4.5)	1 (12.5)	0 (0)	0 (0)
White	16 (72.7)	5 (62.5)	5 (71.4)	6 (75)
Other	1 (4.5)	1 (12.5)	0 (0)	0 (0)
Marital status				
Married or living with significant other	4 (18.2)	1 (14.3)	2 (28.6)	1 (12.5)
Never married/divorced/widowed	17 (77.3)	6 (85.7)	4 (57.1)	7 (87.5)
Other	1 (4.5)	0 (0)	1 (14.3)	0 (0)
Year in school				
Undergraduate	13 (59.1)	7 (100)	2 (28.6)	4 (50)
Graduate	8 (36.4)	0 (0)	4 (57.1)	4 (50)
Not a student	1 (4.5)	0 (0)	1 (14.3)	0 (0)
Living situation				
On-campus or sorority/fraternity house	6 (27.2)	3 (42.9)	1 (14.3)	2 (25)
Off-campus	15 (68.2)	3 (42.9)	6 (85.7)	6 (75)
Other	1 (4.5)	1 (14.3)	0 (0)	0 (0)
Enrolled in meal plan through university	10 (45.5)	6 (85.7) ^a	2 (28.6) ^b	2 (25) ^b
Self-weighing frequency at study entry				
Less than 1 time per month	15 (68.2)	5 (71.4)	6 (85.7)	4 (50)
Monthly	3 (13.6)	0 (0)	0 (0)	3 (37.5)
Weekly	4 (18.2)	2 (28.6)	1 (14.3)	1 (12.5)
Tracking of food at study entry				
Never/Rarely	15 (68.2)	5 (71.4)	5 (71.4)	5 (62.5)
Sometimes/Often	6 (27.3)	2 (28.6)	1 (14.3)	3 (37.5)
Always	1 (4.5)	0 (0)	1 (14.3)	0 (0)
Tracking of physical activity at study entry				
Never/Rarely	9 (40.9)	5 (71.4)	2 (28.6)	2 (25)
Sometimes/Often	7 (31.8)	2 (28.6)	3 (42.8)	2 (25)
Always	6 (27.3)	0 (0)	2 (28.6)	4 (50)

Table 1. Continued.

Characteristic	Total (n=22)	Daily Weighing (n=7)	Weekly Weighing (n=7)	No Weighing Control (n=8)
	← mean ± standard deviation →			
EAT-26 score at study entry	3.9 ± 3.5	3.4 ± 2.1 ^{ab}	1.9 ± 1.1 ^a	6.0 ± 4.7 ^b
BES score at study entry	7.5 ± 5.4	7.4 ± 5.3	4.86 ± 3.2	9.9 ± 6.4
Number of unhealthy weight-control behaviors at study entry	0.1 ± 0.3	0.1 ± 0.4	0.0 ± 0.0	0.1 ± 0.4
SSES score at study entry	78.6 ± 8.8	81.4 ± 5.4	77.1 ± 9.5	77.5 ± 10.9
POMS anxiety subscale score at study entry	4.1 ± 5.0	2.3 ± 2.0	5.4 ± 5.9	4.6 ± 6.0
POMS depression subscale score at study entry	0.8 ± 1.8	0.3 ± 0.8	1.4 ± 2.9	0.6 ± 0.9
Average energy intake at study entry (kcal)	1935 ± 462	2035 ± 354	1983 ± 544	1807 ± 497
Average energy expenditure at study entry (kcal)	2156 ± 339	2367 ± 130	1966 ± 380	2139 ± 356

Note: BMI: Body Mass Index; EAT-26: Eating Attitudes Test-26; BES: Binge Eating Scale; SSES: State Self Esteem Scale; POMS: Profile of Mood States. Superscripts are used to identify pairwise differences that reach Bonferroni-corrected $p < 0.5$.

was significantly lower than participants in the no weighing group (6.0 ± 4.7), $X^2(2) = 6.41$, $p = .035$. No other significant differences between groups were observed at baseline.

Specific Aim 1

Analyses showed no significant main effect or interaction for energy intake. For intake of servings of protein foods, there was a statistically significant main effect of time, $F(2, 20) = 4.5$, $p = .025$. The servings of protein foods consumed at follow-up day 1, day 2, and day 3 were 5.1 ± 0.7 , 4.2 ± 0.6 , and 6.1 ± 0.7 , respectively. Pairwise comparisons showed that the average consumption of servings of protein foods at follow-up day 3 was significantly greater than follow-up day 2 ($p = .011$). However, the average consumption of servings of protein foods did not significantly differ between follow-up day 1 and follow-up day 3 ($p = .652$) or follow-up day 1 and follow-up day 2 ($p = .600$). For intake of servings of dairy, there was a statistically significant interaction effect between weighing group and time, $F(2, 20) = 4.4$, $p = .032$. At follow-up day 2, the no weighing group consumed more servings of dairy (2.3 ± 0.4) than the weighing group (0.9 ± 0.3). There were no significant main effects or interactions for other dietary measures (**Table 2**).

Analyses showed no significant main effect or interaction for energy expenditure. Furthermore, there were no significant main effects or interactions for other physical activity measures (**Table 2**).

Due to significant differences between groups at baseline, a change variable was calculated for the outcome of weight by subtracting weight at baseline from weight at follow-up. An analysis of covariance, with the independent variable as weighing group, dependent variable

Table 2. Dietary and physical activity outcome measures of weighing group and no weighing control at follow-up day 1, day 2, and day 3.

Outcome Measure	Weighing (n = 14)	No Weighing Control (n = 8*)
	← mean ± standard deviation →	
Energy intake (kcal)		
Follow-Up Day 1	2147 ± 814	1528 ± 538
Follow-Up Day 2	1783 ± 647	1880 ± 853
Follow-Up Day 3	1902 ± 543	1893 ± 368
Carbohydrate intake (% total kcal)		
Follow-Up Day 1	51.0 ± 13.3	45.7 ± 10.8
Follow-Up Day 2	51.5 ± 11.7	40.7 ± 6.4
Follow-Up Day 3	46.7 ± 7.7	45.1 ± 8.2
Protein intake (% total kcal)		
Follow-Up Day 1	13.5 ± 3.2	18.3 ± 6.9
Follow-Up Day 2	14.9 ± 6.8	15.2 ± 5.3
Follow-Up Day 3	14.6 ± 3.8	17.3 ± 5.0
Fat intake (% total kcal)		
Follow-Up Day 1	33.3 ± 9.3	36.9 ± 10.7
Follow-Up Day 2	35.6 ± 9.0	41.8 ± 5.9
Follow-Up Day 3	38.5 ± 9.1	37.8 ± 7.4
Dietary fiber intake (g)		
Follow-Up Day 1	21.8 ± 13.5	13.2 ± 6.9
Follow-Up Day 2	19.6 ± 8.3	15.6 ± 7.4
Follow-Up Day 3	20.7 ± 11.1	17.5 ± 10.5
Servings of grains (oz)		
Follow-Up Day 1	7.3 ± 3.7	5.4 ± 2.9
Follow-Up Day 2	6.0 ± 3.1	6.6 ± 5.0
Follow-Up Day 3	6.6 ± 2.9	5.3 ± 2.6
Servings of protein foods (oz)		
Follow-Up Day 1	4.9 ± 3.5	5.7 ± 2.9
Follow-Up Day 2	4.9 ± 3.8	3.5 ± 1.7
Follow-Up Day 3	5.3 ± 3.3	7.2 ± 2.0
Servings of fruit (cups)		
Follow-Up Day 1	0.8 ± 0.8	0.4 ± 0.5
Follow-Up Day 2	0.6 ± 0.7	0.8 ± 0.8
Follow-Up Day 3	0.6 ± 0.7	1.2 ± 1.0
Servings of vegetables (cups)		
Follow-Up Day 1	2.0 ± 1.5	1.4 ± 1.0
Follow-Up Day 2	1.8 ± 1.2	1.9 ± 1.0
Follow-Up Day 3	1.8 ± 1.2	1.8 ± 1.6
Servings of dairy (cups)		
Follow-Up Day 1	1.2 ± 1.0	0.8 ± 1.0
Follow-Up Day 2	0.8 ± 0.7 ^a	2.5 ± 1.5 ^b
Follow-Up Day 3	1.1 ± 0.9	1.3 ± 1.4

Table 2. Continued.

Outcome Measure	Weighing (n = 14)	No Weighing Control (n = 8*)
	← mean ± standard deviation →	
Energy expenditure (kcal)		
Follow-Up Day 1	1824 ± 464	1649 ± 506
Follow-Up Day 2	2323 ± 466	2156 ± 336
Follow-Up Day 3	2067 ± 320	2110 ± 363
Number of steps		
Follow-Up Day 1	5665 ± 4138	5146 ± 2466
Follow-Up Day 2	7815 ± 3307	8536 ± 4863
Follow-Up Day 3	6287 ± 2331	6675 ± 3468
Physical activity duration¹ (hours:minutes)		
Follow-Up Day 1	1:05 ± 0:53	0:43 ± 0:29
Follow-Up Day 2	1:45 ± 1:20	1:20 ± 0:58
Follow-Up Day 3	1:02 ± 0:37	1:06 ± 0:44

Note: 1. Physical activity duration = moderate- to vigorous-intensity physical activity duration (3.0 METs and higher). Superscripts are used to identify pairwise differences that reach Bonferroni-corrected $p < 0.5$. * n=6 for energy expenditure, number of steps, and physical activity duration due to equipment malfunctions.

as the calculated change value, and covariates as baseline weight, baseline EAT-26 score, age, and enrollment in meal plan was conducted for weight. At follow-up, weight changes were $-1.4 \text{ lbs} \pm 3.0$ for the weighing group and $2.8 \text{ lbs} \pm 3.3$ for the no weighing group. These weight changes were statistically significant among groups, $F(1, 20) = 7.66$, $p = .014$ (**Table 3**).

Specific Aim 2

Analyses showed no significant main effect or interaction for energy intake. For intake of servings of protein foods, there was a statistically significant main effect of time, $F(2, 19) = 4.21$, $p = 0.032$. The servings of protein foods consumed at follow-up day 1, day 2, and day 3 were 5.2 ± 0.7 , 4.4 ± 0.6 , and 6.0 ± 0.7 , respectively. Pairwise comparisons showed that the average consumption of servings of protein foods at follow-up day 3 was significantly greater than follow-up day 2 ($p = .041$). However, the average consumption of servings of protein foods did not significantly differ between follow-up day 1 and follow-up day 3 ($p = 1.0$) or follow-up day 1 and follow-up day 2 ($p = .665$). There were no significant main effects or interactions for other dietary measures (**Table 4**).

Analyses showed no significant main effect or interaction for energy expenditure. Furthermore, there were no significant main effects or interactions for other physical activity measures (**Table 4**).

As in specific aim 1, a change variable was calculated for weight for analyses. Weight changes were $-0.4 \text{ lbs} \pm 1.1$ for the daily weighing group, $-2.4 \text{ lbs} \pm 4.0$ for the weekly weighing group, and $2.8 \text{ lbs} \pm 3.3$ for the no weighing group. These weight changes were statistically significant among groups $F(2, 19) = 4.72$, $p = .026$ (**Table 5**). Pairwise comparisons showed that

Table 3. Changes in secondary outcome measures from baseline to follow-up of weighing group and no weighing control.

Outcome Measure	Weighing (n=14)	No Weighing Control (n=8)
	← mean ± standard deviation →	
Weight (lbs)	-1.4 ± 3.0 ^a	2.8 ± 3.3 ^b
EAT-26 score	0.9 ± 1.4	0.0 ± 2.0
BES score	-0.9 ± 2.1	-1.5 ± 2.3
Number of unhealthy weight control behaviors	0.0 ± 0.0	0.1 ± 0.6
SSES score	0.9 ± 8.4	0.9 ± 5.8
POMS anxiety subscale score	0.7 ± 5.3	-0.3 ± 5.8
POMS depression subscale score	1.3 ± 2.4	-0.3 ± 1.2

Note: EAT-26: Eating Attitudes Test-26; BES: Binge Eating Scale; SSES: State Self-Esteem Scale; POMS: Profile of Mood States. Superscripts are used to identify pairwise differences that reach Bonferroni-corrected $p < 0.5$.

Table 4. Dietary and physical activity outcome measures of daily weighing group, weekly weighing group, and no weighing control at follow-up day 1, day 2, and day 3.

Outcome Measure	Daily Weighing (n=7)	Weekly Weighing (n=7)	No Weighing Control (n=8*)
	mean ± standard deviation		
Energy intake (kcal)			
Follow-Up Day 1	2372 ± 1015	1922 ± 536	1528 ± 538
Follow-Up Day 2	1945 ± 752	1623 ± 531	1880 ± 853
Follow-Up Day 3	1908 ± 637	1898 ± 483	1893 ± 368
Carbohydrate intake (% total kcal)			
Follow-Up Day 1	48.5 ± 13.4	53.3 ± 13.7	45.7 ± 10.8
Follow-Up Day 2	51.6 ± 13.2	40.7 ± 6.4	40.7 ± 6.4
Follow-Up Day 3	46.0 ± 8.5	46.4 ± 7.5	45.1 ± 8.2
Protein intake (% total kcal)			
Follow-Up Day 1	13.8 ± 4.4	13.1 ± 1.6	18.3 ± 6.9
Follow-Up Day 2	13.3 ± 5.0	16.6 ± 8.3	15.2 ± 5.3
Follow-Up Day 3	14.1 ± 4.2	15.1 ± 3.6	17.3 ± 5.0
Fat intake (% total kcal)			
Follow-Up Day 1	33.4 ± 7.0	33.1 ± 11.8	36.9 ± 10.7
Follow-Up Day 2	37.0 ± 11.0	34.2 ± 7.2	41.8 ± 5.9
Follow-Up Day 3	40.7 ± 9.6	36.3 ± 8.7	37.8 ± 7.4
Dietary fiber intake (g)			
Follow-Up Day 1	16.7 ± 5.7	26.9 ± 17.3	13.2 ± 6.9
Follow-Up Day 2	20.4 ± 6.8	18.8 ± 10.0	15.6 ± 7.4
Follow-Up Day 3	17.1 ± 6.3	24.2 ± 14.1	17.5 ± 10.5
Servings of grains (oz)			
Follow-Up Day 1	7.7 ± 3.9	6.9 ± 3.8	5.4 ± 2.9
Follow-Up Day 2	7.1 ± 3.5	6.6 ± 5.0	6.6 ± 5.0
Follow-Up Day 3	6.0 ± 3.3	7.2 ± 2.5	5.3 ± 2.6
Servings of protein foods (oz)			
Follow-Up Day 1	4.7 ± 2.4	5.2 ± 4.5	5.7 ± 2.9
Follow-Up Day 2	4.4 ± 3.6	5.4 ± 4.1	3.5 ± 1.7
Follow-Up Day 3	5.3 ± 3.8	5.3 ± 3.0	7.2 ± 2.0
Servings of fruit (cups)			
Follow-Up Day 1	0.4 ± 0.4	1.2 ± 0.9	0.4 ± 0.5
Follow-Up Day 2	0.3 ± 0.4	1.0 ± 0.8	0.8 ± 0.8
Follow-Up Day 3	0.2 ± 0.3	0.9 ± 0.8	1.2 ± 1.0
Servings of vegetables (cups)			
Follow-Up Day 1	2.3 ± 1.5	1.8 ± 1.6	1.4 ± 1.0
Follow-Up Day 2	2.0 ± 1.3	1.7 ± 1.3	1.9 ± 1.0
Follow-Up Day 3	2.4 ± 1.2	1.1 ± 0.9	1.8 ± 1.6
Servings of dairy (cups)			
Follow-Up Day 1	1.6 ± 1.1	0.7 ± 0.7	0.8 ± 1.0
Follow-Up Day 2	0.8 ± 0.8	0.9 ± 0.7	2.5 ± 1.5
Follow-Up Day 3	0.9 ± 0.7	1.3 ± 1.1	1.3 ± 1.4

Table 4. Continued.

Outcome Measure	Daily Weighing (n=7)	Weekly Weighing (n=7)	No Weighing Control (n=8*)
	← mean ± standard deviation →		
Energy expenditure (kcal)			
Follow-Up Day 1	1946 ± 542	1702 ± 372	1649 ± 506
Follow-Up Day 2	2680 ± 371	1966 ± 188	2156 ± 336
Follow-Up Day 3	2248 ± 293	1886 ± 246	2110 ± 363
Number of steps			
Follow-Up Day 1	6459 ± 4512	4872 ± 3908	5146 ± 2466
Follow-Up Day 2	9182 ± 3928	6449 ± 1978	8536 ± 4863
Follow-Up Day 3	6758 ± 1749	5816 ± 2862	6675 ± 3468
Physical activity duration ¹ (hours:minutes)			
Follow-Up Day 1	1:21 ± 0:57	0:49 ± 0:48	0:43 ± 0:29
Follow-Up Day 2	2:39 ± 1:21	0:52 ± 0:28	1:20 ± 0:58
Follow-Up Day 3	1:20 ± 0:40	0:45 ± 0:26	1:06 ± 0:44

Note: 1. Physical activity duration = moderate- to vigorous-intensity physical activity duration (3.0 METs and higher). Superscripts are used to identify pairwise differences that reach Bonferroni-corrected $p < 0.5$. * n=6 for energy expenditure, number of steps, and physical activity duration due to equipment malfunctions.

Table 5. Changes in secondary outcome measures from baseline to follow-up of daily weighing group, weekly weighing group, and no weighing control.

Outcome Measure	Daily Weighing (n=7)	Weekly Weighing (n=7)	No Weighing Control (n=8)
	← mean ± standard deviation →		
Weight (lbs)	-0.4 ± 1.1 ^{ab}	-2.4 ± 2.9 ^a	2.8 ± 3.3 ^b
EAT-26 score	0.9 ± 1.9	0.9 ± 0.9	0.0 ± 2.0
BES score	-1.0 ± 1.6	-0.9 ± 2.6	-1.5 ± 2.3
Number of unhealthy weight control behaviors	0.0 ± 0.0	0.0 ± 0.0	0.1 ± 0.6
SSES score	3.9 ± 4.4	-2.1 ± 10.6	0.9 ± 5.8
POMS anxiety subscale score	-1.1 ± 2.1	2.6 ± 6.9	-0.3 ± 5.8
POMS depression subscale score	0.3 ± 1.5	2.3 ± 2.9	-0.3 ± 1.2

Note: EAT-26: Eating Attitudes Test-26; BES: Binge Eating Scale; SSES: State Self-Esteem Scale; POMS: Profile of Mood States. Superscripts are used to identify pairwise differences that reach Bonferroni-corrected $p < 0.5$.

the weight change in the no weighing group was significantly greater than the weight change in the weekly weighing group ($p = .024$).

Secondary Outcomes of Interest

Due to significant differences between groups at baseline, for secondary outcomes a change variable was calculated by subtracting the measure's value at baseline from the measure's value at follow-up. An analysis of covariance, with the independent variable as weighing group, dependent variable as the calculated change value, and covariates as the measure of interest's value at baseline, baseline EAT-26 score, age, and enrollment in meal plan was conducted for eating attitudes, binge eating, unhealthy weight control behaviors, mood, and self-esteem.

Eating Attitudes, Binge Eating, Unhealthy Weight Control Behaviors

Analyses showed no statistically significant differences between groups, weighing and no weighing control, as well as daily weighing, weekly weighing and no weighing control, in the change in EAT-26 score, BES score, or number of unhealthy weight control behaviors from baseline to follow-up (**Table 3** and **Table 5**).

Mood and Self-Esteem

Analyses showed no statistically significant differences between groups, weighing and no weighing control, as well as daily weighing, weekly weighing and no weighing control, in the change in POMS anxiety subscale score, POMS depression subscale score, or SSES score from baseline to follow-up (**Table 3** and **Table 5**).

Follow-Up Questionnaire

Most participants mentioned that they were aware of their natural weight fluctuations, so a slight increase or decrease in their weight from day to the next, or one week to the next, did not cause them to change their eating or physical activity habits.

...I didn't respond too much because I know my weight fluctuates especially based on hormones and my anxiety level

...Weight fluctuates. My routine/eating habits didn't change. My attitude didn't change.

...I wouldn't change much, my weight seemed to fluctuate a lot...

I don't think I responded to this/did anything different (it was only a small change).

Participants in the daily weighing group mentioned that their weight fluctuates more often than participants in the weekly weighing group and, therefore, stated they did not make changes to their eating or physical activity habits. Several participants in the weekly weighing group who stated they did not make changes to their eating or physical activity habits when their weight changed explained that when their weight did change, "it was only a small change" or "there was never a significant increase."

Some participants stated they would make small changes to their eating or physical activity habits if their weight changed. If their weight went up, some participants stated they would increase exercise, eat more vegetables, cut out snacking, or pay more attention to their hunger and satiety cues: "It made me more aware of what I ate or was eating. I paid more attention to my hunger/satiety cues. [I] increased exercise." If their weight went down, some participants stated they may have an extra snack or dessert (such as a square of chocolate or ice cream) or add something to their diet: "I felt a little worried that I may not be eating enough due to stress/anxiety. I tried to add something to my diet." Participants in the weekly weighing group

reported making these behavior changes in response to changes in weight more frequently than participants in the daily weighing group. If participants' weights remained the same, most participants in both the daily and weekly weighing groups stated they would try to maintain their diet and physical activity behaviors from the previous day or week: "I would just keep doing whatever I did the previous day."

Overall, participants in both the daily and weekly weighing groups did not report any negative effects of weighing themselves. One participant in the weekly weighing group stated some increase in thoughts about weight when weight increased: "...but I did think about it some. I thought about which part of my body looked different." Several participants in both the daily and weekly weighing groups reported positive feelings when their weight decreased: "I was happy and felt proud of myself." Several participants also reported positive feelings when their weight remained the same: "I was happy to see my weight remain the same because my goal is to maintain my weight."

Process Evaluation

The average compliance to the weighing intervention for all participants in the daily weighing group ($n = 7$) was $93.5\% \pm 11.9\%$. The average compliance to the weighing intervention for participants in the weekly weighing group ($n = 7$) was $100\% \pm 0\%$. The difference in compliance between the two intervention groups was not significant ($p = .184$). After removing one participant in the daily weighing group who was non-compliant with the start of the weighing intervention (began weighing daily on day 8 instead of day 14 but did not start receiving feedback on weight via email until day 15), the average compliance to the

weighing intervention for the daily weighing group ($n = 6$) was $93.2\% \pm 12.4\%$. The difference in compliance between the two intervention groups remained non-significant ($p = .173$).

Discussion

This study examined if self-weighing with feedback provokes changes in diet and physical activity behaviors, and if the frequency of self-weighing and feedback influences changes in diet and physical activity behaviors among a sample of young adults seeking to maintain their weight. Over a 5-week period, there was no evidence that self-weighing with feedback provoked changes in diet and physical activity behaviors. While there were significant differences in servings of protein foods consumed over time and differences in diary consumption over time between the no weighing and weighing groups, these results are not clinically significant in regard to energy balance. However, the 5-week self-weighing with feedback intervention did aid in weight control as the weighing group had significantly less weight gain than the no weighing control group. Frequency of self-weighing with feedback also appeared to influence weight control as the weekly weighing group gained significantly less weight than the no weighing group, but there were no differences in weight change between the daily weighing group and no weighing group. Lastly, this study did not find that self-weighing with feedback had any unwanted negative psychological effects in regard to disordered eating behaviors and cognitions, mood, and self-esteem.

These findings support the study by Gow and colleagues³⁸ which found no differences in their trial in dietary intake (assessed via food screener) and physical activity (assessed via a self-reported questionnaire) in their groups that differed in self-weighing frequency and weight

outcomes.³⁸ Most participants in the present study stated they did not change their behaviors when their weight changed because they are aware that their weight fluctuates, and the few small changes participants did make to their diet and physical activity behaviors most likely were not adequately captured by 24-hour dietary recalls and the SenseWear Armband. There is wide variability in energy intake and energy expenditure among individuals, so a small change in energy balance equal to 150 calories is most likely not going to be captured with the current dietary and physical activity assessment tools available. This could explain the lack of significant dietary and physical activity results.

This study supports numerous research studies that indicate self-weighing with feedback can aid in weight control.^{34,35,38,39} Furthermore, it appears that for effective weight control, the action of self-weighing must be paired with immediate feedback in which daily weighing is followed by daily feedback, and weekly weighing is followed by weekly feedback.^{35,38,38} Previous research shows that daily weighing with daily feedback can assist in weight control,³⁹ but daily weighing with weekly feedback may not be effective for weight control.^{35, 38} It was unclear whether weekly weighing paired with weekly feedback would aid in weight control, but the results of the present study suggests weekly weighing with weekly feedback may be effective for weight control. This may be because the one-week time frame between each weighing with feedback is a long enough period for weight changes to be better reflection of true changes in energy balance. For daily weighing with feedback, it may be difficult to determine if weight change is a result of normal weight fluctuations versus a true change in energy balance. Therefore, a person who sees their weight change over a week may attribute it to an actual change in energy balance and be more inclined to make changes to their diet and physical

activity behaviors versus a person who sees their weight change day to day may attribute it to normal weight fluctuations and be less inclined to make changes to their diet and physical activity behaviors.

The results of the present study indicate that there are no unintended consequences to self-weighing with feedback. This aligns with an abundance of previous experimental research that has shown self-weighing by healthy individuals who are free of eating pathologies does not result in negative psychological consequences relating to disordered eating cognitions, mood, and self-esteem^{30,48-50} The qualitative results of the present study suggest that self-weighing with feedback was primarily viewed in a neutral or positive manner by both daily weighers and weekly weighers, and people are aware that weight naturally fluctuates. Zheng et al. (2018)⁶⁶ came to similar conclusions. When participants who completed a 12-month weight loss intervention study that included daily self-weighing described their experiences with daily weighing, they expressed several positive aspects to daily self-weighing, and they were aware of normal weight fluctuations.⁶⁶

One limitation of this study is its short duration. This study was five weeks in duration, and the active intervention took place during four out of the five weeks. Therefore, it is unclear how self-weighing with feedback and the frequency of self-weighing with feedback influences long-term weight maintenance. In addition, the sample size was relatively small and homogenous, consisting of primarily white, female participants of a healthy weight. Consequently, the findings' generalizability is limited to young adult, white females of a healthy weight who are seeking to maintain their current weight. Results may be different for individuals of different weight statuses and those wanting to lose weight. Individuals with overweight or

obesity seeking weight loss may make more drastic changes to their diet and physical activity behaviors as a result of self-weighing with feedback. Furthermore, they may also experience more positive psychological outcomes as weight loss occurs and they make progress towards their weight goal. Lastly, as can be expected with any research study using technology, there were some equipment malfunctions throughout the course of the research study. The SenseWear Armband malfunctioned while collecting follow-up data on two occasions which resulted in a smaller final analytic sample for physical activity outcomes.

A noteworthy strength of this study was the use of ASA24 for dietary recalls and SenseWear Armbands for physical activity measures. The few studies that have previously examined diet and physical activity outcomes used very broad measures of dietary intake (using food screeners) and self-reported measures of physical activity.^{25,38} The measures used in this study provided a more in-depth assessment to investigate how people respond to feedback on weight. This study also used Bluetooth Yunmai SE Smart Scales that provided a record of date and time-stamped weights for each intervention participant instead of relying on self-reported weights. This also allowed for an objective assessment of participants' compliance to the intervention. While self-reported weighing frequency has been shown to be modestly correlated with objective weighing frequency, it is recommended that objective weighing frequency, such as what was used in the present study, should be used to avoid overestimating actual frequency.⁶⁷

Conclusion

In conclusion, the results of this study indicate that self-weighing with feedback aids in weight control among individuals who are a healthy weight seeking to maintain their weight.

Specifically, weekly weighing with feedback resulted in a significant weight loss over five weeks while no weighing resulted in a significant weight gain. However, it remains unclear what changes individuals make to their diet and physical activity behaviors in response to self-weighing with feedback, although qualitative responses from participants suggest they adopt strategies such as increasing exercise or adding/removing snacks to maintain their weight. Participants in this study indicated that they are aware of natural weight fluctuations and, therefore, did not usually engage in behaviors to manipulate their weight. When recommending self-weighing to individuals who wish to maintain their weight, it may be beneficial to provide education on normal weight fluctuations and advise persons to focus on trends in weight rather than day-to-day weight fluctuations.

Future studies are needed to determine the long-term benefits of self-weighing with feedback. In addition, exploring what type of feedback, such as personalized messages or a graph of weight trends, is most beneficial for weight control is also needed. Future studies are also needed to further explore what self-reaction occurs following self-weighing with feedback. Exploring these concepts among males and diverse ethnic populations is also needed.

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Appendices

Appendix A – Participant Timeline

Timeline uploaded as a separate attachment.

Appendix B – ASA24 Instructions

Guide uploaded as a separate attachment.

Appendix C – Armband Instructions

Guide uploaded as a separate attachment.

Appendix D – Nutrition Information

Handout uploaded as a separate attachment.

Appendix E – Yunmai SE Scale Instructions

Guide uploaded as a separate attachment.

Appendix F – 150 Calorie Statements

Decrease 150 Calories:

1. Cut out one 12oz. soda from your day and replace it with water or another low-calorie (less than 5 calories per serving) beverage
2. Instead of eating a calorie-dense, sweet food (i.e. cake, brownies, cookies, pie, candy, etc.), eat a piece of fresh fruit
3. Order a tall latte instead of a venti latte
4. Choose a small side salad (without cheese, nuts/seeds, croutons, or creamy full fat dressing) or a piece of fresh fruit with your meal instead of fries or chips
5. Use mustard on your sandwich instead of mayonnaise
6. Have 2 slices of thin-crust pizza instead of 2 slices of thick-crust or deep-dish pizza
7. Choose 1 cup of nonfat Greek yogurt instead of 1 cup of regular ice cream
8. Cut out one 8oz. glass of fruit juice from your day and replace it with water or another low-calorie (less than 5 calories per serving) beverage
9. Go on a 30-minute walk
10. Play basketball for 15-20 minutes
11. Dance for 30 minutes
12. Swim for 15-20 minutes
13. Weightlift for 25 minutes
14. Use an elliptical machine for 25 minutes
15. Go on a bike ride for 20-25 minutes
16. Have half of a large bagel (i.e., size at Panera) for breakfast instead of a whole bagel
17. Add lettuce and tomato to your wrap, sandwich, or hamburger and skip the cheese (1 oz.)
18. Skip the nuts or seeds on your yogurt, oatmeal, cereal, or salad
19. Replace your snack of potato chips with crunchy baby carrots (8) or plain microwave-popcorn (1 cup)
20. Choose a lettuce wrap instead of a tortilla wrap

Increase 150 Calories:

1. Add half of a medium avocado to your sandwich or salad
2. Snack on 1/4 cup of nuts
3. Add 1.5 tbs. peanut butter or another nut butter to your smoothie
4. Add an extra slice of cheese (1oz) to your wrap, sandwich, or hamburger
5. Sprinkle 1/4 cup of nuts or seeds on your yogurt, oatmeal, cereal, or salad
6. Sauté vegetables or pan-fry meat in 1 tbs. of olive oil or canola oil
7. Add an 8oz glass of 100% fruit juice to your meal or as a snack
8. Top vegetables, potatoes, casseroles, soups, sandwiches, and salads with 1/3 cup of cheese
9. Add an 8oz glass of 2% milk to your meal or as a snack
10. Add 1/4 cup of beans to salads, soups, or casseroles
11. Add 1/3 cup of granola to your yogurt
12. Add a snack of 1/4 cup of trail mix to your day

13. Add a snack of 2 tbs. of hummus with 1 oz. pretzels (approx. 13 pretzels) to your day
14. Add 1.5 oz. of dried fruit to your oatmeal or salad, or have as a snack
15. Add 2/3 cup of cooked quinoa to your salad or soup
16. Add 1.5 tbs. peanut butter to your apple or banana
17. Add a snack of 1 oz. whole grain cereal (i.e., Cheerios) to your day
18. Add two eggs to your day (add scrambled eggs to your breakfast, include hardboiled eggs to salads, eat hardboiled eggs at snacks)
19. Add a whole grain English Muffin to your breakfast
20. Add 1 cup of nonfat plain yogurt to your breakfast or snack

Appendix G – Demographic Questionnaire

1. AGE _____

2. SEX: ☐ MALE ☐ FEMALE
 (1) (2)

3. EDUCATION: Check your current year in school.

- ☐ (1) Freshman
- ☐ (2) Sophomore
- ☐ (3) Junior
- ☐ (4) Senior
- ☐ (5) 5th year or greater
- ☐ (6) Graduate student
- ☐ (7) N/A (not a student)

4. MARITAL STATUS:

- ☐ (1) Married
- ☐ (2) Separated
- ☐ (3) Divorced
- ☐ (4) Widowed
- ☐ (5) Never Married
- ☐ (6) Not Married (living with significant other)
- ☐ (7) Other (specify): _____

6. LIVING SITUATION:

- ☐ (1) On-campus
- ☐ (2) Off-campus
- ☐ (3) Sorority or fraternity house
- ☐ (4) Other (specify): _____

7. Which of the following best describes your ethnic heritage?

- ☐ (1) Hispanic or Latino
- ☐ (2) Not Hispanic or Latino

8. Which of the following best describes your racial heritage? (you may choose more than one)

- ☐ (1) American Indian or Alaskan Native
- ☐ (2) Asian
- ☐ (3) Black or African American
- ☐ (4) Native Hawaiian or other Pacific islander
- ☐ (5) White
- ☐ (6) Other (specify): _____

9. Do you have a meal plan through the university?

- ☐ (1) No
- ☐ (2) Yes

10. How often do you weigh yourself?

- ☐ (1) Less than 1 time per month
- ☐ (2) Every month
- ☐ (3) A few times per month
- ☐ (4) Every week
- ☐ (5) A few times per week
- ☐ (6) Every day
- ☐ (7) More than 1 time per day

11. Do you keep track of your eating (i.e. use a mobile app like MyFitnessPal to record your food intake, keep a food log/food journal)?

- ☐ (1) Never
- ☐ (2) Rarely
- ☐ (3) Sometimes
- ☐ (4) Often
- ☐ (5) Always

12. Do you keep track of your physical activity (i.e. wear a fitness tracker like Fitbit, keep an exercise journal)?

- ☐ (1) Never
- ☐ (2) Rarely
- ☐ (3) Sometimes
- ☐ (4) Often
- ☐ (5) Always

Appendix H – EAT-26

Please check a response for each of the following statements:

	Always	Usually	Often	Sometimes	Rarely	Never
1. I am terrified about being overweight.	☐	☐	☐	☐	☐	☐
2. I avoid eating when I am hungry.	☐	☐	☐	☐	☐	☐
3. I find myself preoccupied with food.	☐	☐	☐	☐	☐	☐
4. I have gone on eating binges where I feel that I may not be able to stop.	☐	☐	☐	☐	☐	☐
5. I cut my food into small pieces.	☐	☐	☐	☐	☐	☐
6. I am aware of the calorie content of the foods that I eat.	☐	☐	☐	☐	☐	☐
7. I particularly avoid food with a high carbohydrate content (i.e. bread, rice, potatoes, etc.)	☐	☐	☐	☐	☐	☐
8. I feel that others would prefer if I ate more.	☐	☐	☐	☐	☐	☐
9. I vomit after I have eaten.	☐	☐	☐	☐	☐	☐
10. I feel extremely guilty after eating.	☐	☐	☐	☐	☐	☐
11. I am preoccupied with a desire to be thinner.	☐	☐	☐	☐	☐	☐

12. I think about burning up calories when I exercise.	☐	☐	☐	☐	☐	☐
13. Other people think that I am too thin.	☐	☐	☐	☐	☐	☐
14. I am preoccupied with the thought of having fat on my body.	☐	☐	☐	☐	☐	☐
15. I take longer than others to eat my meals.	☐	☐	☐	☐	☐	☐
16. I avoid foods with sugar in them.	☐	☐	☐	☐	☐	☐
17. I eat diet food.	☐	☐	☐	☐	☐	☐
18. I feel that food controls my life.	☐	☐	☐	☐	☐	☐
19. I display self-control around food.	☐	☐	☐	☐	☐	☐
20. I feel that others pressure me to eat.	☐	☐	☐	☐	☐	☐
21. I give too much time and thought to food.	☐	☐	☐	☐	☐	☐
22. I feel uncomfortable after eating sweets.	☐	☐	☐	☐	☐	☐
23. I engage in dieting behavior.	☐	☐	☐	☐	☐	☐
24. I like my stomach to be empty.	☐	☐	☐	☐	☐	☐
25. I have the impulse to vomit after meals.	☐	☐	☐	☐	☐	☐

26. I enjoy trying new rich foods

☐☐☐☐☐☐

Appendix I – BES

Below are groups of numbered statements. Read all of the statements in each group and mark the one that best describes the way you feel about the problems you may have controlling your eating behavior. If none of the statements apply, please leave that number blank.

- 1) ☐ I don't feel self-conscious about my weight or body size when I'm with others.
☐ I feel concerned about how I look to others, but it normally does not make me feel disappointed with myself.
☐ I do get self-conscious about my appearance and weight which makes me feel disappointed in myself.
☐ I feel very self-conscious about my weight and frequently, I feel intense shame and disgust for myself. I try to avoid social contacts because of my self-consciousness.
- 2) ☐ I don't have any difficulty eating slowly in the proper manner.
☐ Although I seem to "gobble down" foods, I don't end up feeling stuffed because of eating too much.
☐ At times, I tend to eat quickly and then, I feel uncomfortably full afterwards.
☐ I have the habit of bolting down my food, without really chewing it. When this happens I usually feel uncomfortably stuffed because I've eaten too much.
- 3) ☐ I feel capable to control my eating urges when I want to.
☐ I feel like I have failed to control my eating more than the average person.
☐ I feel utterly helpless when it comes to feeling in control of my eating urges.
☐ Because I feel so helpless about controlling my eating I have become very desperate about trying to get in control.
- 4) ☐ I don't have the habit of eating when I am bored.
☐ I sometimes eat when I'm bored, but often I'm able to "get busy" and get my mind off food.
☐ I have a regular habit of eating when I'm bored, but occasionally, I can use some other activity to get my mind off eating.
☐ I have a strong habit of eating when I'm bored. Nothing seems to help me break the habit.
- 5) ☐ I'm usually physically hungry when I eat something.
☐ Occasionally, I eat something on impulse even though I really am not hungry.
☐ I have the regular habit of eating foods, that I might not really enjoy, to satisfy a hungry feeling even though physically, I don't need the food.
☐ Even though I'm not physically hungry, I get a hungry feeling in my mouth that only seems to be satisfied when I eat a food, like a sandwich, that fills my mouth. Sometimes, when I eat the food to satisfy my mouth hunger, I then spit the food out so I won't gain weight.

- 6) ☐ I don't feel any guilt or self-hatred after I overeat.
☐ After I overeat, occasionally I feel guilt or self-hate.
☐ Almost all the time I experience strong guilt or self-hate after I overeat.
- 7) ☐ I don't lose total control of my eating when dieting even after periods when I overeat.
☐ Sometimes when I eat a "forbidden food" on a diet, I feel like I "blew it" and eat even more.
☐ Frequently, I have the habit of saying to myself, "I've blown it now, why not go all the way" when I overeat on a diet. When that happens I eat even more.
☐ I have a regular habit of starting strict diets for myself, but I break the diets by going on an eating binge. My life seems to be either a "feast" or "famine."
- 8) ☐ I rarely eat so much food that I feel uncomfortably stuffed afterwards.
☐ Usually about once a month, I eat such a quantity of food, I end up feeling very stuffed.
☐ I have regular periods during the month when I eat large amounts of food, either at mealtime or at snack.
☐ I eat so much food that I regularly feel quite uncomfortable after eating and sometimes a bit nauseous.
- 9) ☐ My level of calorie intake does not go up very high or go down very low on a regular basis.
☐ Sometimes after I overeat, I will try to reduce my caloric intake to almost nothing to compensate for the excess calories I've eaten.
☐ I have a regular habit of overeating during the night. It seems that my routine is not to be hungry in the morning but overeat in the evening.
☐ In my adult years, I have had week-long periods where I practically starve myself. This follows periods when I overeat. It seems I live a life of either "feast or famine."
- 10) ☐ I usually am able to stop eating when I want to. I know when "enough is enough."
☐ Every so often, I experience a compulsion to eat which I can't seem to control.
☐ Frequently, I experience strong urges to eat which I seem unable to control, but at other times I can control my eating urges.
☐ I feel incapable of controlling urges to eat. I have a fear of not being able to stop eating voluntarily.
- 11) ☐ I don't have any problem stopping eating when I feel full.
☐ I usually can stop eating when I feel full but occasionally I overeat which leaves me feeling uncomfortably stuffed.
☐ I have a problem stopping eating once I start and usually I feel uncomfortably stuffed after I eat a meal.
☐ Because I have a problem not being able to stop eating when I want, I sometimes have to induce vomiting to relieve my stuffed feeling.

- 12) ☐ I seem to eat just as much when I'm with others (family, social gatherings) as when I'm by myself.
☐ Sometimes, when I'm with other persons, I don't eat as much as I want to eat because I'm self-conscious about my eating.
☐ Frequently, I eat only a small amount of food when others are present, because I'm very embarrassed about my eating.
☐ I feel so ashamed about my overeating that I pick times to overeat when I know no one will see me. I feel like a "closet eater."
- 13) ☐ I eat three meals a day with an occasional between meal snack.
☐ I eat 3 meals a day, but I also normally snack between meals.
☐ When I am snacking heavily, I get in the habit of skipping regular meals.
☐ There are regular periods when I seem to be continually eating, with no planned meals.
- 14) ☐ I don't think much about trying to control unwanted eating urges.
☐ At least some of the time, I feel my thoughts are pre-occupied with trying to control my eating urges.
☐ I feel that frequently I spend much time thinking about how much I ate or about trying not to eat anymore.
☐ It seems to me that most of my waking hours are pre-occupied by thoughts about eating or not eating. I feel like I'm constantly struggling not to eat.
- 15) ☐ I don't think about food a great deal.
☐ I have strong cravings for food but they last only for brief periods of time.
☐ I have days when I can't seem to think about anything else but food.
☐ Most of my days seem to be pre-occupied with thoughts about food. I feel like I live to eat.
- 16) ☐ I usually know whether or not I'm physically hungry. I take the right portion of food to satisfy me.
☐ Occasionally, I feel uncertain about knowing whether or not I'm physically hungry. At these times it's hard to know how much food I should take to satisfy me.
☐ Even though I might know how many calories I should eat, I don't have any idea what is a "normal" amount of food for me.

Appendix J – Unhealthy Weight Control Behaviors

Have you done any of the following things in order to lose weight or keep from gaining weight during the past **4 weeks**?

	Yes	No
1. Fasted	☐	☐
2. Ate very little food	☐	☐
3. Used a food substitute (e.g. Slim-fast)	☐	☐
4. Skipped meals	☐	☐
5. Smoked more cigarettes	☐	☐
6. Took diet pills	☐	☐
7. Made yourself vomit	☐	☐
8. Used laxatives	☐	☐
9. Used diuretics	☐	☐

Appendix K – SSES

This is a questionnaire designed to measure what you are thinking at this moment. There is of course, no right answer for any statement. The best answer is what you feel is true of yourself at the moment. Be sure to answer all of the items, even if you are not certain of the best answer. Again, answer these questions as they are true for you **RIGHT NOW**.

	Not At All	A Little Bit	Somewhat	Very Much	Extremely
1. I feel confident about my abilities.	☐	☐	☐	☐	☐
2. I am worried about whether I am regarded as a success or failure.	☐	☐	☐	☐	☐
3. I feel satisfied with the way my body looks right now.	☐	☐	☐	☐	☐
4. I feel frustrated or rattled about my performance.	☐	☐	☐	☐	☐
5. I feel that I am having trouble understanding things that I read.	☐	☐	☐	☐	☐
6. I feel that others respect and admire me.	☐	☐	☐	☐	☐
7. I am dissatisfied with my weight.	☐	☐	☐	☐	☐
8. I feel self-conscious.	☐	☐	☐	☐	☐
9. I feel as smart as others.	☐	☐	☐	☐	☐

10. I feel displeased with myself.	☐	☐	☐	☐	☐
11. I feel good about myself	☐	☐	☐	☐	☐
12. I am pleased with my appearance right now.	☐	☐	☐	☐	☐
13. I am worried about what other people think of me.	☐	☐	☐	☐	☐
14. I feel confident that I understand things.	☐	☐	☐	☐	☐
15. I feel inferior to others at this moment.	☐	☐	☐	☐	☐
16. I feel unattractive.	☐	☐	☐	☐	☐
17. I feel concerned about the impression I am making.	☐	☐	☐	☐	☐
18. I feel that I have less scholastic ability right now than others.	☐	☐	☐	☐	☐
19. I feel like I'm not doing well.	☐	☐	☐	☐	☐
20. I am worried about looking foolish.	☐	☐	☐	☐	☐

Appendix L – POMS

Below is a list of words that describe feelings people have. Please **MARK THE RESPONSE THAT BEST DESCRIBES HOW YOU FEEL RIGHT NOW**.

	Not At All	A Little	Moderately	Quite a lot	Extremely
Tense	☐	☐	☐	☐	☐
Unhappy	☐	☐	☐	☐	☐
Sad	☐	☐	☐	☐	☐
On-edge	☐	☐	☐	☐	☐
Hopeless	☐	☐	☐	☐	☐
Uneasy	☐	☐	☐	☐	☐
Restless	☐	☐	☐	☐	☐
Discouraged	☐	☐	☐	☐	☐
Nervous	☐	☐	☐	☐	☐
Miserable	☐	☐	☐	☐	☐
Anxious	☐	☐	☐	☐	☐
Helpless	☐	☐	☐	☐	☐
Worthless	☐	☐	☐	☐	☐

Vita

Genevieve Louise Prushinski was born in Princeton, IL and graduated from Princeton High School in 2013 as valedictorian of her class. In the fall, Genevieve enrolled at Bradley University (Peoria, IL). She graduated summa cum laude in May 2017 with dual-B.S. degrees in dietetics and psychology. Genevieve conducted undergraduate research investigating the prevalence and predictors of the “freshman fifteen” under the guidance of Dr. Amanda Newell and Dr. Claire Etaugh. She began her graduate studies (M.S. in public health nutrition) and dietetic internship at The University of Tennessee (Knoxville, TN) in August 2017.