Examining the Relationships Between Weight-Related Self-Monitoring and Eating Disorder Risk Among College Students

by

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Dedication

This dissertation is dedicated to my late aunt, Pamela Dean Hahn, who is the reason that I decided to pursue a career in nutrition and eating disorder prevention research.

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Abstract

Weight-related self-monitoring involves tracking one's weight, physical activity, and/or dietary intake. Millions of individuals engage in weight-related self-monitoring, with college students among the most likely users. Despite widespread weight-related self-monitoring, there is little research evaluating its consequences. Of particular concern is the potential for weight-related self-monitoring to increase eating disorder risk. The aims of this dissertation were to: 1) understand how undergraduate and graduate college students use methods of dietary self-monitoring and self-weighing with one another, and examine whether certain patterns of weight-related self-monitoring methods are associated with eating disorder risk, 2) examine how college freshmen use technology-based weight-related self-monitoring, and determine how patterns of technology-based weight-related self-monitoring are associated with eating disorder behaviors, and 3) identify the extent to which technology-based dietary self-monitoring increases eating disorder risk among female undergraduate students. Aim 1 drew from a large cohort of students from 12 universities across the United States and used latent class analysis to identify patterns of weight-related self-monitoring. Methods of weight-related self-monitoring that were assessed included knowing nutrition facts, knowing calorie facts, counting calories, and self-weighing. Eating disorder risk was measured using the Eating Disorder Examination Questionnaire. Results of Aim 1 suggest differences in patterns of weight-related self-monitoring by gender. Among females, four patterns were identified: "no weight-related self-monitoring", "all weight-related self-monitoring" methods, "knowing nutrition/calorie facts", and "self-weigh only". For females, all patterns of weight-related self-monitoring were associated with higher eating disorder risk

compared to “no weight-related self-monitoring”. Among males, three patterns were identified: “no weight-related self-monitoring”, “all weight-related self-monitoring” methods, and “all weight-related self-monitoring but calorie counting”. Among males, only those represented by the “all weight-related self-monitoring” pattern demonstrated elevated risk for eating disorders. For Aim 2, latent class analysis was again used to identify patterns in use of the following weight-related self-monitoring tools: apps for a specific diet or exercise plan, wearable fitness tracker, online fitness tracker, online food journal, self-weighing, and a weight tracking app. Three patterns of technology-based weight-related self-monitoring were identified among females: “no weight-related self-monitoring”, “all weight-related self-monitoring”, and “food and exercise self-monitoring”. Those categorized by the “all weight-related self-monitoring” pattern were more likely to engage in eating disorder behaviors than those in the “no weight-related self-monitoring” pattern. Among males, three patterns were also identified: “no weight-related self-monitoring”, “all weight-related self-monitoring”, and “exercise self-monitoring”. There were no relationships between these patterns and eating disorder behaviors among males. Finally, for Aim 3, undergraduate female students were randomly assigned to either monitor their eating for 30 days using the MyFitnessPal app or continue to be naïve to dietary self-monitoring. Eating disorder risk was measured using the EDE-QS at baseline and post-intervention. No difference in eating disorder risk was seen between groups at post-intervention, suggesting that participating in a 30-day trial of dietary self-monitoring did not affect eating disorder risk among undergraduate females. Overall, findings from this dissertation indicate that specific patterns of weight-related self-monitoring are associated with concurrent eating disorder risk, particularly among women. Assessing methods of weight-related self-monitoring among young adults may be useful to identify individuals at elevated risk for eating disorders. However,

a short-term trial of dietary self-monitoring among college women naïve to dietary self-monitoring did not increase eating disorder risk immediately post-intervention. Future research is needed to understand whether there are any specific sub-populations for whom weight-related self-monitoring is problematic.

Chapter 1 : Introduction

Self-monitoring in public health

Supporting sustained behavior change is a fundamental component of many public health interventions. One method used to induce and sustain behavior change is self-monitoring, which involves recording or keeping track of the behaviors that one is seeking to improve. Social cognitive theory posits that self-monitoring is essential to build the self-regulation skills that are required for behavior change.[1,2] Self-monitoring is a key component in self-regulation as people cannot gain motivation or know how to change their actions if they are not aware of their current behaviors.[1] By engaging in self-monitoring, individuals are able to become conscious of their current behaviors, allowing for them to set goals for behavior change, and then evaluate their progress towards those goals, thereby building self-regulation skills. Specifically for health, self-monitoring allows individuals to identify behaviors that they believe need to be changed, to monitor how their behaviors have changed over time, but also how their behavior changes affected their downstream health.[3] Indeed self-monitoring has been successfully used in a variety of health behavior change contexts, including reducing cigarette smoking,[4] improving sleep hygeine,[5] and medication adherence.[6] Because of the sound theoretical underpinning of self-monitoring and empirical support for success,[4-8] it has been considered a key component of behavior change for an array of public health outcomes among varied populations.

What is weight-related self-monitoring?

Weight-related self-monitoring is a form of self-monitoring that includes mentally keeping track of or physically recording aspects that may affect one's weight or weight itself.

There are three main types of weight-related self-monitoring: monitoring one's 1) weight 2) physical activity and/or 3) dietary intake. Self-monitoring of one's weight, also known as self-weighing, can involve recording one's weight over time or keeping track of one's weight mentally without the need to physically record it. Monitoring of physical activity can include keeping track of the amount of physical activity completed, with or without calories burned during the exercise. Self-monitoring of dietary intake is arguably the most complex form of weight-related self-monitoring and can involve simply knowing the nutrient or caloric composition of foods prior to eating them, tracking the types of foods eaten every day, or monitoring the calories and/or nutrient composition of the foods consumed.

Historically, weight-related self-monitoring consisted of physically recording these aspects on paper or keeping track mentally. Technology has expanded the scope of weight-related self-monitoring substantially and has also simplified the amount of time and cognitive burden required to self-monitor. For example, physical activity self-monitoring now often involves wearable physical activity trackers that count steps, heart rate, and/or calories burned from physical activity. Similarly, dietary self-monitoring is often conducted using smartphone applications (apps) or using the internet to find nutrition or calorie facts, and self-weighing can use Wi-Fi scales connected to smartphone apps. Different forms of weight-related self-monitoring can be used by themselves or in conjunction with one another, with technology making it easier than ever to track more than one aspect in the same smartphone app. While weight-related self-monitoring encompasses a variety of behaviors, the underlying concept is the same: monitoring weight and/or behaviors that affect weight.

Who uses weight-related self-monitoring?

Healthcare providers and individuals in the scientific community have long recommended the use of weight-related self-monitoring as a main component of behavioral interventions for weight loss among those with high body weights.[9] Weight-related self-monitoring is thought to be an effective behavioral weight management intervention because it brings attention to an individual's physical activity and dietary behaviors, which are often over and under estimated, respectively.[10,11] As discussed previously, self-monitoring uses data to encourage critical self-reflection on current behaviors with the intent of changing future behavior.[12] Individuals who self-monitor are then able to attribute weight changes to their actions, thereby building self-regulatory skills.[3] Many studies have found that weight-related self-monitoring can be an effective method for weight loss among individuals with higher body weights.[2,13-16] As a result, clinical guidelines for the management of higher body weight in adults includes self-monitoring one's weight, physical activity, and dietary intake as a primary component of the behavioral intervention.[9]

The use of weight-related self-monitoring has also become popular outside of the clinical context. In recent years, apps such as MyFitnessPal (a digital dietary tracker) and devices such as Fitbit (a wearable activity tracker) that offer technologically advanced methods of weight-related self-monitoring have flourished, thereby increasing accessibility of weight-related self-monitoring to the general public. MyFitnessPal and its affiliated smartphone apps have amassed over 165 million users since coming onto the market,[17] with over 19 million active users a month.[18] Furthermore, Fitbit has sold millions of devices worldwide[19] and has 27.4 million active users a month.[18] A study conducted in 2012 found that 24% of young adults use health apps on their phones and, of those, 38% use an app to monitor their exercise or physical activity,

31% use an app to monitor their dietary intake, and 12% use an app to track their weight.[20] Young adults and those with some college education are the most likely to use health apps,[20] and college students are more likely than their non-student peers to use various forms of technology including cell phones and laptops, where these weight-related self-monitoring tools are particularly prominent.[21] Therefore, it is likely that college students are among the most likely to be using weight-related self-monitoring tools, particularly digital forms.

Potential consequences of weight-related self-monitoring

Weight-related self-monitoring and eating disorder risk

While there have been numerous studies examining the potential benefits of weight-related self-monitoring, possible negative consequences have been understudied. Of particular concern is the potential for weight-related self-monitoring to increase eating disorder risk. Eating disorders are characterized by a preoccupation with food, weight, and/or shape, and the aim of self-monitoring is to draw attention to food and exercise and how they affect an individual's weight. It has been hypothesized that the additional focus on weight and behaviors that affect weight may increase eating disorder risk by increasing attention to the criticisms individuals have about their body.[22,23] If individuals are satisfied with their body, they may be less compelled to change their body due to this increased attention to their body. Therefore, those with pre-existing body dissatisfaction may be more susceptible to the harms of weight-related self-monitoring and therefore would have even more negative associations between weight-related self-monitoring and eating disorder risk compared to their body satisfied counterparts.

Self-weighing

Nearly all prior studies examining the relationship between weight-related self-monitoring and eating disorder risk have focused on self-weighing. Self-weighing is cross-

sectionally associated with a number of negative psychological outcomes among college students and young adults including higher eating disorder risk,[24] as well as poor body image, weight preoccupation,[25] and body dissatisfaction,[26,27] which are independent risk factors for eating disorders. Frequent self-weighing is also cross-sectionally associated with dieting and unhealthy weight control behaviors among young men and women, and binge eating among young men.[27] Self-weighing is also common among those with eating disorders, with those engaging in more self-weighing having higher eating disorder severity.[28]

Longitudinal and randomized controlled trials examining the effects of self-weighing on eating disorder risk have had mixed results. In one longitudinal study of young adults, increases in self-weighing were associated with increases in weight concern among both men and women and increases in depression and decreases in body satisfaction and self-esteem among women.[29] However, because this study examined simultaneous changes in self-weighing and the outcomes of interest, the findings cannot provide insight as to whether the increase in self-weighing preceded the negative beliefs and behaviors. One randomized controlled trial conducted among thirty female college students found that self-weighing outside of a structured weight management program increased anxiety and depression, and decreased self-esteem and body satisfaction.[23] Meanwhile, other randomized controlled trials conducted among weight loss seeking samples have found no associations between self-weighing and negative psychological outcomes including depression, drive for thinness, and body dissatisfaction.[30-32] However, the mean age in two of the three samples with null results were over 45 years old and the results may not be comparable to college students.[30,32] A recent meta-analysis showed that there was no overall association between self-weighing and disordered eating, but the findings suggest that self-weighing may be particularly harmful for disordered eating among younger samples, such as

college students.[33] Overall, the literature suggests that self-weighing may be particularly harmful for younger samples, such as college students, and those who are not part of a structured weight loss program.

Physical activity and dietary self-monitoring

The relationships between physical activity tracking, dietary tracking, and eating disorder risk has only recently been examined in a small number of cross-sectional studies. Among a clinical sample of patients with eating disorders, 75% had used MyFitnessPal and 73% of app users believed that the use of MyFitnessPal had contributed to their eating disorder.[34] Among a non-clinical sample of males, those that used of MyFitnessPal experienced higher risk of eating disorders and also endorsed that the use of MyFitnessPal contributed to their eating disorder behaviors.[35] However, when looking specifically at college students, there have only been three studies examining the relationship between dietary or physical activity self-monitoring and eating disorder risk. Simpson and Mazzeo found that calorie tracking was associated with eating concern and dietary restraint, and that fitness tracking was associated with eating disorder risk and symptomology among college students.[36] Further, college students who monitored their food and activity had higher compulsive exercise and eating disorder risk than those who did not monitor, particularly those that reported using self-monitoring tools for weight or shape purposes.[37] Additionally, one study found that frequent self-weighing and calorie counting were associated with increased eating disorder risk among college students.[38] However, these studies were cross-sectional. Because the current literature is exclusively cross-sectional, we are unable to determine temporality and therefore, causation.

Among the very minimal existing research there has been strong and consistent cross-sectional associations between weight-related self-monitoring and eating disorder risk; these

associations may due to several factors which may be acting independently or may be co-occurring. Firstly, it could be that there is indeed a causal relationship between weight-related self-monitoring and eating disorder risk or that it is harmful for certain sub-populations, but not everyone. Also, it may be reverse causality is at play and that individuals who are high risk for eating disorders are engaging in weight-related self-monitoring as a result of their elevated eating disorder risk. Additionally, it may be that there is unmeasured confounding that are not being corrected for which are leading to inaccurate associations (see conceptual model, Figure 1.1). For example, weight perception is associated with likelihood of using eating disorder behaviors.[39] Those that believe themselves to be overweight are also more likely to try to lose weight which may confound the relationship between weight-related self-monitoring and eating disorder risk, as weight-related self-monitoring is often used as a tool for weight loss.[40] Using weight-related self-monitoring as a means for dieting for weight loss may also confound the relationship as dieting is a known risk factor for eating disorders.[41,42] Additionally, studies conducted to date have used self-reported height and weight to calculate body mass index. However, weight is more often underreported for those in larger bodies leading to potentially insufficient adjustment for body mass index.[43] There also may be shared risk factors between weight-related self-monitoring and eating disorder risk such as preoccupation with weight and/or shape and food. Individuals who are preoccupied with weight and/or shape and food may be more likely to engage in weight-related self-monitoring as well as have an increased risk for an eating disorder. Internalization of the thin ideal might also be a factor to consider as internalization of the thin ideal is associated with increases in body-image and eating disturbances.[44] Further, personality traits such as perfectionism, which is linked to elevated eating disorder risk, may be more likely to use weight-related self-monitoring due to their attraction of having goals and being more

likely concerned with making mistakes.[45] However, we do not know whether such traits are also associated with weight-related self-monitoring and should be examined in future studies as potential confounders. Longitudinal studies measuring potential confounders and randomized controlled trials are needed to further elucidate the findings from the current limited number of cross-sectional studies examining this relationship. Overall, there has been inadequate research examining the relationships between weight-related self-monitoring and eating disorder risk, particularly among populations that are likely using these tools the most, such as college students.

Multiple forms of weight-related self-monitoring

Only one study to date has examined how different forms of weight-related self-monitoring are used in conjunction with one another. The researchers found that calorie counting and physical activity self-monitoring are often used simultaneously, but the study did not include other forms of weight-related self-monitoring or examine if there is differential eating disorder risk based on the patterns of use.[36] In fact, prior research has shown that patterns of behaviors can have differential risk on a number of mental and physical health outcomes.[46,47] Therefore, it is likely that various forms of weight-related self-monitoring are used together and it is likely that there is differential risk based on the patterns of weight-related self-monitoring, though this has never been studied.

Eating disorder risk among college students

College students are likely the population using weight-related self-monitoring most frequently,[20,21] and they are also at high risk for eating disorders, including full and partial syndrome eating disorders and engaging in eating disorder behaviors.[48,49] The mean age of onset for anorexia nervosa, bulimia nervosa and binge eating disorder fall within the period of young

adulthood (19, 20 and 25 years old, respectively) which correspond with the usual age range of college students.[50,51] It is estimated that 8-23% of college students are struggling with either a partial or full-syndrome eating disorder.[52-55] Additionally, eating disorder behaviors such as misusing laxatives, diuretics, and diet pills, self-induced vomiting, fasting, skipping meals, and binge eating, are common among college students. One study found that 40% of college students had binge eaten and 30% had used compensatory behaviors such as vomiting, laxatives, diet pills, diuretics, or compulsive exercise in the four weeks prior to surveying.[49]

Full syndrome eating disorders are debilitating illnesses that affect nearly every aspect of life. They are associated with role impairment,[50] and are often co-morbid with other mental health issues including increased risk for suicidality,[56] anxiety disorders, and substance use disorders.[50] Eating disorders are also associated with negative physical health effects including increased mortality,[57] gastrointestinal distress and dysfunction,[58] cardiac arrhythmias,[59] diminished bone mineral density[60] and many other medical consequences.[61] Moreover, sub-threshold eating disorders and engaging in eating disorder behaviors also have deleterious health effects including blunted cortisol and cardiovascular reactions to acute stress,[62] gastrointestinal dysfunction,[63] weight gain,[64] increased psychological distress over time,[65] decreased educational attainment,[66] increased classroom impairment,[67] and increased likelihood of binge drinking.[68] Eating disorders are preventable diseases,[69-74] and through understanding what impacts eating disorder risk, we will be better suited to tailor existing interventions and develop new approaches to preventing eating disorders. Further, college campuses offer a unique ability to target and implement public health interventions to at-risk students. The likely high use of weight-related self-monitoring, vulnerable period for eating disorder onset, and the means to intervene

underscores the public health relevance of understanding how weight-related self-monitoring impacts eating disorder risk among college students.

The literature examining the relationship between weight-related self-monitoring and eating disorder risk among college students is limited and warrants future research. Given the high prevalence of use and proliferation of tools to engage in weight-related self-monitoring, it is imperative to understand how college students are using weight-related self-monitoring. However, there is a lack of rigorous epidemiological studies that describe college students' use of weight-related self-monitoring. The data that exist come from cross-sectional studies conducted at single institutions which may not be generalizable to college students throughout the country. Further, there is a lack of studies examining how weight-related self-monitoring behaviors are used together, and how that impacts risk.

Only one study to date has examined how different forms of weight-related self-monitoring are used in conjunction with one another. The researchers found that dietary and physical activity self-monitoring are often used simultaneously, but the study did not include other forms of weight-related self-monitoring or examine if there is differential eating disorder risk based on the patterns of use.[36] Due to the rapid emergence of technologies to engage in weight-related self-monitoring, it is imperative to understand how these tools are used in conjunction with one another and how their use impacts risk. Understanding these relationships will provide valuable understanding that will lay the foundation for future longitudinal and experimental studies. Moreover, due to the lack of randomized controlled trials examining the relationship between weight-related self-monitoring and eating disorder risk among this population, causality cannot be established.

Dissertation Aims and Hypotheses

The overarching objective of this dissertation is therefore to characterize college students' use of weight-related self-monitoring and to examine the relationships between weight-related self-monitoring and eating disorder risk in this population. The findings from this project have the potential to inform public health messaging surrounding weight-related self-monitoring and eating disorder prevention interventions. Aim 1 is conducted using the Healthy Bodies Study, a cross-sectional survey conducted among twelve colleges and universities in the United States. Aim 2 uses data from a survey of University of Michigan freshmen. Aim 3 is conducted among a recruited sample of undergraduate University of Michigan females.

The first aim of this dissertation is to identify patterns of use of various forms of dietary self-monitoring and self-weighing among a large sample of college students and to determine (1) if there are differences in these patterns by age, body mass index (BMI), race/ethnicity, and parental education, (2) whether identified patterns of use are associated with eating disorder risk, and (3) whether body dissatisfaction moderates this relationship. We hypothesized that different patterns of weight-related self-monitoring would show differential associations with eating disorder risk, but that all patterns of weight-related self-monitoring would be associated with increased eating disorder risk compared to no weight-related self-monitoring. Further, we believe that body dissatisfaction would moderate this relationship with those being body dissatisfied having further elevated eating disorder risk compared to those who are body satisfied. Examining the relationship between patterns of weight-related self-monitoring behaviors and eating disorder risk will provide novel knowledge on the associations between eating disorder risk and the patterns of use of dietary self-monitoring and self-weighing. This will provide greater understanding of how different patterns of use and not just singular forms of

dietary self-monitoring, particularly dietary self-monitoring, impacts eating disorder risk among a large sample of graduate and undergraduate students.

The second aim identifies patterns of use of digitally based forms of weight-related self-monitoring among a sample of university freshmen, assesses whether these patterns of use differ by age, BMI, race/ethnicity, and parental education, and whether the identified patterns are associated with eating disorder risk. We hypothesized that the identified patterns of weight-related self-monitoring would be have differential eating disorder risk with increased odds of eating disorder risk among all groups compared to no weight-related self-monitoring. These data will provide valuable and novel knowledge on the associations between eating disorder risk and the patterns of digitally based weight-related self-monitoring. This information will make valuable contributions to the current literature on the relationships between weight-related self-monitoring and eating disorder risk, particularly by examining technologically advanced methods of weight-related self-monitoring and by exploring patterns of behaviors that occur rather than singular behaviors.

Aim 3 is a randomized controlled trial testing whether using MyFitnessPal for one-month impacts eating disorder risk among a sample of University of Michigan females who are dietary self-monitoring naïve. We hypothesized that using MyFitnessPal would increase eating disorder risk among this sample of females. This aim will provide evidence of potential causal relationships between dietary self-monitoring and eating disorder risk among this population.

Understanding patterns of weight-related self-monitoring use and their potential impact on eating disorder risk among college students is of public health importance given that college students are highly susceptible to eating disorders and the unique ability of colleges to implement policies and interventions to prevent eating disorders. The present dissertation will provide

valuable information about weight-related self-monitoring among college students. In addition to describing the use of weight-related self-monitoring among two samples of college students, the rigorous epidemiological methods to be employed will offer unique insight into the complex relationships between weight-related self-monitoring and eating disorder risk among college students. By going beyond examining singular behaviors and identifying patterns of use of various forms of weight-related self-monitoring, we will be able to assess the associations between how these behaviors are used in these populations and eating disorder risk. Further, the randomized controlled trial will provide the highest quality examination of the potentially causal effects of dietary self-monitoring on eating disorder risk among an epidemiologically vulnerable population. The information gained from this dissertation has the potential to not only increase our understanding of the complex relationship between weight-related self-monitoring and eating disorder risk but may have broader public health impact. The study may inform how colleges discuss weight-related self-monitoring by providing strong scientific evidence on the potential negative consequences, if any, and how they identify or target individuals at risk for eating disorders. Further, results may help inform the public health recommendations for weight-related self-monitoring, and the widespread use of weight-related self-monitoring.

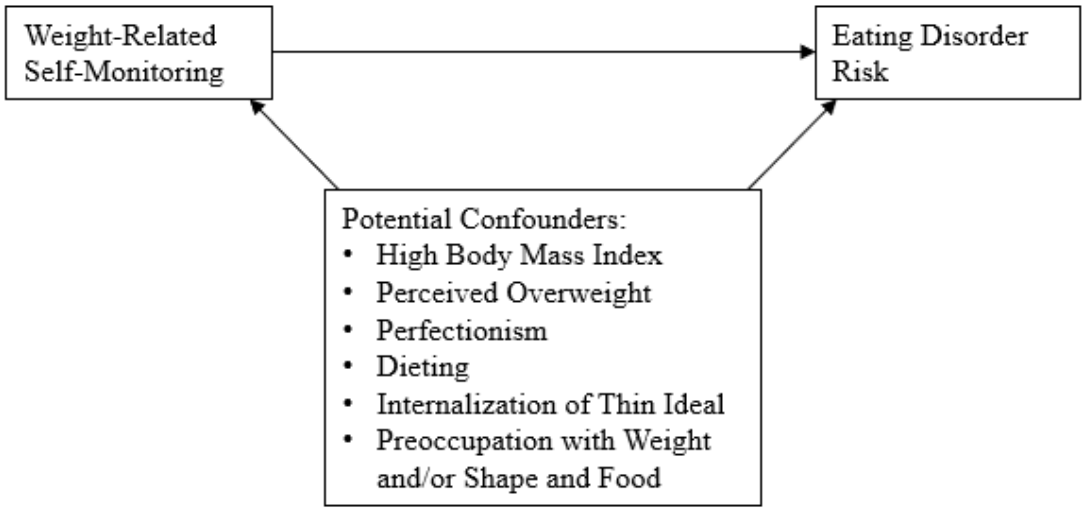

Figure 1.1 Conceptual Model of the Relationship Between Weight-Related Self-Monitoring and Eating Disorder Risk

Chapter 2 : Relationships Between Patterns of Weight-Related Self-Monitoring and Eating Disorder Risk Among Undergraduate and Graduate College Students

Introduction

Eating disorders are widespread and their prevalence has increased over time.[75] The usual age range of college years directly coincides with the mean age of onset for anorexia nervosa (19 years old), bulimia nervosa (20 years old), and binge eating disorder (25 years old)[50,51] and an estimated 8-23% of college students are currently struggling with a full-syndrome eating disorder.[52-55] Further, many more college students are engaging in subthreshold eating disorder behaviors. For example, in one study of undergraduate and graduate students 30.2% reported engaging in compensatory behaviors such as vomiting, laxative use, diet pills or diuretics, or compulsive exercise and 40.2% had binge eaten in the four weeks prior to being surveyed.[49] College students who engage in eating disorder behaviors are at risk of a number of negative physical and mental health consequences including psychological distress,[65] classroom impairment,[67] decreased educational attainment,[66] substance abuse[50], and increased mortality.[57]

Despite the high prevalence of eating disordered behaviors among college students, the college years and college setting offers great potential for eating disorder prevention activities. One hypothesized modifiable risk factor for eating disorders relevant to this population is weight-related self-monitoring. Weight-related self-monitoring involves tracking one's weight (also known as self-weighing) or behaviors that affect weight, such as dietary intake. Approximately 30-35% of college students engage in self-weighing at least once per week[25,76] and 13.8% report using a calorie counting device or application.[36] Weight-related self-

monitoring is commonly used to support behavior change with the goal of reducing weight. It is thought to be an effective means to support behavior change because it brings attention to an individual's behaviors and how their behaviors affect weight.[1,2] However, among populations vulnerable to eating disorders, the increased attention to food and weight may lead to a pathological obsession with these factors.[22] Specifically, weight-related self-monitoring may be particularly problematic for people who are body dissatisfied, as the increased attention to weight may exacerbate negative body image and may compel them to engage in disordered weight control behaviors.[23]

Despite the plausible rationale, the impacts of weight-related self-monitoring on eating disorder risk among college students remains unclear. Some cross-sectional studies have found that college-age individuals who engage in self-weighing are more likely to experience heightened eating disorder risk,[24] weight preoccupation,[25] and body dissatisfaction compared to those who do not weigh themselves.[26,27] However, other studies have found no relationship between self-weighing and eating disorder risk,[30-32] though the generalizability of these studies is limited because these studies were conducted in weight loss seeking samples in the context of a weight management trial. A recent meta-analysis found that self-weighing was generally not associated with adverse psychological outcomes, but that younger samples such as college students may be most vulnerable to adverse effects such as disordered eating among.[33] Additionally, the authors concluded that the social support included in weight management trials may have negated any potential negative consequences of self-weighing.[33]

Beyond self-weighing, calorie counting is the next most common form of self-monitoring studied among college students. Prior studies have shown calorie counting is associated with eating concern, dietary restraint,[36] and increased eating disorder risk[38] among this population.

Meanwhile, other forms of dietary self-monitoring such as knowing the nutrient or caloric content of the foods they eat have not yet been studied and warrant further research. Further, weight-related self-monitoring behaviors have exclusively been studied in isolation of one another, despite the fact that they commonly co-occur.[36] It is plausible that engaging in multiple forms of weight-related self-monitoring may have synergistic effects and, therefore, different patterns of use may have differential associations with eating disorder risk.

Given these gaps in our understanding of weight-related self-monitoring among college students, the objectives of the present study were to, 1) characterize the patterns of United States undergraduate and graduate students' use of dietary self-monitoring and self-weighing using latent class analysis (LCA), a common analytic approach used within eating disorder[77-82] and health behavior[83-86] research to characterize patterns of behaviors, 2) to examine the associations between identified patterns of weight-related self-monitoring and eating disorder risk among this population, and 3) to determine the extent to which body dissatisfaction moderates these relationships. Findings from this study could help inform targeted and universal eating disorders prevention activities on college campuses.

Methods

Participants

Data for the present study comes from the Healthy Bodies Study (HBS). HBS surveyed students from two- and four-year colleges and universities in the United States and Canada during the 2013-2014 and 2014-2015 school years, with the goal of identifying the prevalence and correlates of eating disorder risk among undergraduate and graduate students (herein referred to as college students). Institutions were recruited to participate by email, contact at academic conferences, and institutions initiating contact with the study team themselves. There were no

exclusion criteria for institutions to participate. After institutions agreed to participate in HBS, the survey was electronically distributed to a randomly selected sample of 4,000 undergraduate and/or graduate students at each institution, the only exclusionary criteria for participants was that they had to give consent. The ratio of undergraduate to graduate students invited to participate was commensurate with the ratio at that institution and it was only sent to individuals 18 years or older. One institution had less than 4,000 students and therefore all students at that institution were invited to participate. Data from one Canadian institution was removed for the present study; thus, the data for the proposed study comes from twelve colleges or universities in the United States. In total, across the twelve participating schools, 10,209 students completed the HBS survey, which corresponded to response rates of 19% and 27% for the respective school years. No students were sent the survey both years. Students were asked to self-report their weight and height, from which body mass index (BMI) was calculated. Students with biologically implausible weight, height, BMI, or age (n=73) were excluded from the analytic sample.[87-89] Students who identified as a gender other than male or female were also excluded as there were too few to make valid gender-specific inferences (n=123). The final analytic sample was 10,010 students. Research approval was obtained by the Institutional Review Boards at the participating institutions.

Measures

Weight-Related Self-Monitoring. Two forms of weight-related self-monitoring were measured in HBS: dietary self-monitoring and self-weighing. Dietary self-monitoring was assessed using three survey items: “How often do you typically know the nutrition facts (for example, fat, fiber, carbohydrates, protein) about the foods and drinks you consume before you consume them?”, “How often do you typically know the number of calories in the foods and

drinks that you consume before you consume them?", and "How often do you count the calories that you consume?". Response options for all three questions were "always", "usually", "sometimes", "rarely" and "never". Each form of dietary self-monitoring was dichotomized with those answering "always" or "usually" considered positive for the respective type of dietary self-monitoring. Self-weighing was assessed using a single item, "About how often do you weigh yourself?" Response options included: "Never", "Less than once per month", "2 to 3 times per month", "once per week", "2 to 3 times per week", "4 to 6 times per week", "once per day" and, "more than once per day". A positive response for the dichotomized variable included individuals who indicated they weighed themselves at least once per week based on clinical guidelines as well as to align with work that has been done prior in self-weighing.[9,90,91]

Eating Disorder Risk. Eating disorder risk was assessed using the Eating Disorder Examination Questionnaire (EDE-Q), the gold standard measure of eating disorder risk in survey research.[92] The EDE-Q is a 28-item measure that assesses eating disorder behaviors and cognitions. In the current study, an EDE-Q global score greater than or equal to three was considered high risk. Among undergraduate women, a cut-off of three indicates approximately 85th percentile of EDE-Q scores, and given the public health importance of both sub-threshold and full syndrome eating disorders, we elected to use an EDE-Q score of three or greater to characterize those in our sample at elevated eating disorder risk.[49,93] A cut-off of three has been used in this population before[49] and still indicates very high risk as it is well above the average for undergraduate men (mean of 0.95) [94] and women (mean of 1.74).[93] In addition to the EDE-Q global score, specific eating disorder behaviors for weight or shape control ascertained by the EDE-Q including fasting (8 or more waking hours without eating), vomiting to compensate, taking diet pills or diuretics, abusing laxatives, and compulsively exercising were assessed where

each ascertained by single item measures and using the behavior one or more days indicated a positive response in the dichotomized variables. Binge eating was assessed using two measures, "Over the past 28 days, how many times have you eaten what other people would regard as an unusually large amount of food (given the circumstances)?" and ". …On how many of these times did you have a sense of having lost control over your eating (at the time that you were eating)?" indicating at least one time for both questions indicated a positive response for binge eating.

Body Dissatisfaction. To assess body dissatisfaction, we used two questions from the EDE-Q: "Over the past 28 days, how dissatisfied have you been with your weight?" and "Over the past 28 days, how dissatisfied have you been with your shape?". Response options ranged from "not at all" to "markedly" with seven possible response options. Individuals who said they were moderately to markedly dissatisfied with either their weight or shape were categorized as body dissatisfied.

Demographics. The literature suggests that eating disorder risk differs by gender,[52,53] race/ethnicity,[52,53] age,[49] BMI,[95] and parental education.[96] Therefore, the following variables were included as demographic covariates: age (continuous), gender (dichotomous), race/ethnicity (categorical: non-Hispanic white, non-Hispanic black, Hispanic/Latinx, non-Hispanic Asian, other), highest parental education by either parent (categorical: high school or less, some college or an associate's degree, bachelor degree, graduate degree), and BMI (both categorical and continuous).

BMI was operationalized as a categorical variable in addition to a continuous variable due to the different public health suggestions for weight-related self-monitoring by BMI category.[9] Age was assessed with the question, "How old are you?" which was open ended and

included an area for them to enter their age in the format "___ years old". Gender was assed via the question, "What is your gender identity", with the response options: "female", "male", "transgender female-to-male", "transgender male-to-female", "genderqueer/gender non-conforming", and "other". Gender was then dichotomized to female and male based on the response options. Race/ethnicity was determined by two questions 1) "Do you consider yourself to be of Hispanic, Latina/o, or Spanish origin?" which was a yes/no question and 2) "How do you usually describe your race? (select all that apply)" and had response options of "White", "Black or African American", Asian or Asian American", "American Indian, Native American, or Alaskan Native", "Middle Eastern, Arab, or Arab American", "Pacific Islander", "Hawaiian Native", and "other". Students who answered "yes" to the first question was categorized as Hispanic/Latinx, all others who selected more than one race were included in the "other" category, as were the individuals who answered, "American Indian, Native American, or Alaskan Native", "Middle Eastern, Arab, or Arab American", "Pacific Islander", "Hawaiian Native", and "other". Highest parental education was determined by combining two questions 1) "What is the highest level of education completed by your mother?" and 2) "What is the highest level of education completed by your father"? both had response options of "graduate", "bachelor's", "associate's", "some college", "high school", "<high school", and "I don't know". The highest parental education for either parent was used, with those who answered that they didn't know for both parents being marked as missing. BMI was calculated using the student's self-report height and weight which were assessed using, "What is your current height?" and "what is your current weight", participants were able to answer in either centimeters or feet and inches for weight and either pounds or kilograms for weight.

Statistical Analyses

All analyses were conducted using SAS 9.4. Analyses were gender stratified based on the a priori hypothesis that the associations between weight-related self-monitoring and eating disorder risk would differ by gender, as gender is a predictor of eating disorder risk.[36,52,53]

Descriptive Statistics. Univariate and bivariate statistics were computed for weight-related self-monitoring, eating disorder risk, body dissatisfaction, and all demographic variables. The descriptive statistics corrected for non-response to the original survey using response probability weights. Response probability weights were calculated by comparing the demographic characteristics of those who were sent the survey versus those who responded. Demographics used to calculate the probability weight included gender, academic level per university records, race/ethnicity, and the school reported grade point average of the student. Using response probability weights increases generalizability of the findings to the sample the survey was sent to, and thus the entire university, instead of the sample that responded to the survey.

Latent Class Analysis. Latent class analysis (LCA) was used to identify weight-related self-monitoring profiles. Gender stratified analyses were used to identify gender-specific patterns of weight-related self-monitoring. All four forms of weight-related self-monitoring assessed in the survey were included in the LCA. Because the seed in PROC LCA[97] can alter results, ten seeds were ran of two through six classes for both genders using randomly generated seed numbers that remained consistent for both genders. For each analysis, the Bayesian Information Criteria (BIC) and Akaike's Information Criterion (AIC) were used to select the best fitting models.[97] Because there were several models with equal or nearly equal BIC and AIC (5 for females and 7 for males), models were examined to determine whether the models had similar groupings of behaviors and assessed for interpretability. The overall best model was then

selected for each gender using a comprehensive approach, taking into account AIC, BIC, and interpretability.

Bivariate Analyses. After selecting the latent classes, chi-square and Fisher's exact tests were used to determine if there were differences in categorical demographic variables across latent classes. For continuous demographic variables, ANOVA was used to compare means across latent classes. If overall tests of differences were statistically significant at $p<.05$, post-hoc pairwise comparisons were conducted between latent classes utilizing logistic regression for categorical variables and t-tests for continuous variables. All bivariate analyses took into account the response probability weights. To reduce likelihood of Type 1 error due to multiple comparisons results were considered significant if $p<.01$,

Logistic Regression and Probabilities. Unadjusted and adjusted logistic regression models were used to examine associations between the weight-related self-monitoring latent classes, global eating disorder risk as measured by the EDE-Q, and individual eating disorder behaviors. Adjusted models included the demographic covariates described above to reduce the potential for confounding. The predicted probability of eating disorder risk was calculated for members of each latent class from each unadjusted and adjusted model.

To examine the extent to which the relationships between weight-related self-monitoring class and eating disorder risk varies by body dissatisfaction, additional regression models were then developed that included body dissatisfaction and an interaction term (body dissatisfaction * weight-related self-monitoring latent classes). The odds ratio and 99% confidence intervals for each interaction term are reported. If the estimate for the interaction term was statistically significant at $p<.01$, stratified models for high versus low body dissatisfaction were run. Because

assessment of body satisfaction uses items from the EDE-Q, models with an interaction term for the EDE-Q global score ≥ 3 were not run.

Results

Description of the Study Sample

Descriptive statistics of the weighted sample can be found in Table 2.1. The sample was 55.1% female and 44.9% male. Approximately two thirds of participants identified as non-Hispanic White (66.9%), 4.4% as African American, 9.3% as Hispanic or Latinx, 11.4% as Asian, and 7.9% as another racial/ethnic identity. Ten percent (10.1%) of students had parents with a high school diploma or less, 17.2% had some college or an associate's degree, 30.3% had a bachelor's degree, and 42.5% had a graduate degree. The average BMI was 24.0 (standard error = 0.1), with 4.4% having a BMI less than 18.5, 64.1% having a BMI of at least 18.5 but less than 25, 22.1% had a BMI of at least 25 but less than 30, and 9.3% having a BMI of 30 or higher. The average age of the sample was 23.9 years old.

Prevalence of predictor, outcome, and moderator variables in the overall sample and by gender can be found in Table 2.2. Among this sample of college students, a similar proportion of females and males reported knowing the nutrition facts of the foods they ate (44.8% of females and 43.3% of males). More females (35.7%) than males (31.1%) knew the calories in the food they consumed ($p < .0001$). Females were also more likely to count calories than males (14.8% versus 10.4%, $p < .0001$). Additionally, females were more likely to have an EDE-Q score ≥ 3, have fasted, vomited, taken diet pills/diuretics, abused laxatives, binge eaten, and be body dissatisfied. However, there was no difference in the prevalence of compulsive exercise by gender.

Latent Class Analysis

Females. Fit statistics for LCA are located in Table 2.3. Using AIC, BIC, and interpretability, four latent classes using seed 431461 was deemed the superior model. Probability estimates of each type of weight-related self-monitoring for each latent class can be found in Figure 2.1. For females, Latent Class 1 was characterized by low likelihood of engaging in any form of weight-related self-monitoring (identified as "no weight-related self-monitoring") and comprised 50.1% of the sample. Latent Class 2 was characterized by high likelihood of all forms of included weight-related self-monitoring (identified as "all weight-related self-monitoring") and comprised 15.0% of the sample. Latent Class 3 was characterized by high likelihood of knowing nutrition facts and knowing calories (identified as "knowing nutrition/calorie facts") and comprised 19.0% of the sample. Latent Class 4 was characterized by high likelihood of self-weighing but low likelihood of all forms of dietary self-monitoring (identified as "self-weighing only") and comprised 15.9% of the sample.

Males. Fit statistics for all models can be found in Table 2.4. A model with three latent classes using seed 431461 was deemed superior based on the AIC, BIC, and interpretability. Probability estimates of the use of weight-related self-monitoring within each latent class can be found in Figure 2.2. In the latent classes identified using LCA, Latent Class 1 was characterized by low probability of all weight-related self-monitoring behaviors (identified as "no weight-related self-monitoring") and constituted 52.2% of the sample; Latent Class 2 was characterized by high probability of all included forms of weight-related self-monitoring (identified as "all weight-related self-monitoring") and constituted 9.7% of the sample, and Latent Class 3 was characterized by high probability of knowing nutrition facts, knowing calories, and frequent self-weighing, but not counting calories (identified as "all weight-related self-monitoring but calorie counting"), and constituted 38.0% of the sample.

Bivariate Analysis Between Latent Class and Demographics

Females. Results from analyses examining demographic characteristics of latent classes among females can be found in Table 2.5. There were differences in race/ethnicity by latent class (X^2=35.7, p=.0004). The "no self-monitoring" class contained a larger proportion of individuals who identify as non-Hispanic Black or African American than the "self-weighing only" class. However, there were no differences in the proportion of non-Hispanic Black or African Americans among the "all weight-related self-monitoring" (3.4%) or "knowing nutrition/calorie facts" (3.9%) compared to either the "no weight-related self-monitoring" or "self-weighing only" classes. There were no differences in the probability of class membership among non-Hispanic White, Hispanic/Latina, non-Hispanic Asian, or those that identified as another race.

Parental education did not differ across latent classes (X^2=4.8, p=.85) and thus, no pairwise comparisons were conducted. However, differences in latent class membership were observed by participants' weight status (X^2=69.2, p<.0001). Those with a BMI less than 18.5 were more likely to belong to the "no weight-related self-monitoring" class compared to all other classes. The proportion of individuals with a BMI 18.5-24.9 was lowest in the "all weight-related self-monitoring" and "self-weigh only" classes. Individuals with a BMI of 25-29.9 were less likely to belong to the "no weight-related self-monitoring" class compared to the "all weight-related self-monitoring" and "knowing nutrition/calorie facts" classes. The proportion of individuals with a BMI of 30 or greater was highest among the "all weight-related self-monitoring" class. When examining BMI as a continuous variable, the trends are similar, with a higher average BMI among the "all weight-related self-monitoring" class compared to the "no weight-related self-monitoring" and "knowing nutrition/calorie facts" classes.

Mean age differed by latent class ($p<.0001$), with females in the "all weight-related self-monitoring" class and "self-weigh only" class being on average older than the "no weight-related self-monitoring" and "knowing nutrition/calorie facts" classes.

Males. Results from the bivariate analyses among males can be found in Table 2.6. Non-Hispanic Asian students were more likely to be in the "all weight-related self-monitoring" class than the other classes. In pairwise analyses, no other significant racial/ethnic differences were seen in pairwise comparisons. In addition, parental education did not differ among latent classes ($X^2=8.9$, $p=0.18$) and therefore, no pairwise comparisons were made.

Unlike parental education, the relationship between categorical BMI and latent class was significant ($X^2=55.0$, $p<.0001$). The proportion of individuals with a BMI less than 18.5 did not differ across the latent classes. However, individuals with a BMI of 18.5-24.9 were more likely to belong in the "no weight-related self-monitoring" class compared to the other classes. The proportion of individuals with a BMI 25-29.9 was nearly twice as high in the "all weight-related self-monitoring" class compared to the "no weight-related self-monitoring class". There were no differences among those with a BMI of 30 or above. The mean BMI was different for all three classes with the highest mean BMI being in the "all weight-related self-monitoring" class, followed by the "all but calorie counting" class, and lowest in the "no weight-related self-monitoring" class.

The overall test found that mean age also differed by latent class ($p=.004$). Pairwise comparisons found that participants in the "all weight-related self-monitoring but calorie counting" class were the oldest on average, and specifically older than those in the "no weight-related self-monitoring" class. However, there was no difference between the "all weight-related self-monitoring" class and the other two classes.

Logistic Regressions and Probabilities

Females. Unadjusted and adjusted associations between weight-related self-monitoring and eating disorder risk are presented in Table 2.7. After adjusting for age, race/ethnicity, highest parental education, and BMI, the probability of having an EDE-Q ≥ 3 was lowest among females in the "no weight-related self-monitoring" class at 7.6%, followed by 18.3% in the "self-weigh only" class, 22.6% in the "know nutrition/calorie facts" class, and 39.9% in the "all weight-related self-monitoring" class. The probability of high eating disorder risk as defined by having an EDE-Q ≥ 3 differed between all of the classes.

For all of the individual eating disorder behaviors, the probability of engaging in a given behavior was lowest in the "no weight-related self-monitoring" class, highest in the "all weight-related self-monitoring" class, and similar for the "know nutrition/calorie facts" and "self-weigh only" classes.

Among females, body dissatisfaction did not moderate any of the relationships between weight-related self-monitoring and eating disorder risk (Table 2.8).

Males. Results from unadjusted and adjusted models can be found in Table 2.9. For EDE-Q ≥ 3, vomiting, diet pills/diuretics, and binge eating, the predicted probability was highest among those in the "all weight-related self-monitoring" class, and there were no difference between the predicted probabilities for the "no weight-related self-monitoring" or "all weight-related self-monitoring but counting calories" classes. The proportion of individuals who reported fasting and misusing laxatives was lowest in the "no weight-related self-monitoring" class, highest in the "all weight-related self-monitoring" class, and the "all weight-related self-monitoring but calorie counting" did not differ from either of the other classes. Compulsive exercise probability differed in all three classes, with the "no weight-related self-monitoring"

having less than half of the probability compared to the “all weight-related self-monitoring” class, and the probability among the “all weight-related self-monitoring but counting calories” fell in the middle.

Similar to females, no differences in associations between latent class membership and eating disorder risk were observed for men with high versus low body dissatisfaction (Table 2.10).

Discussion

The objective of this study was to categorize the ways in which college students self-monitor their eating and weight, examine the associations between patterns of weight-related self-monitoring and eating disorder risk among this population, and to identify whether these associations varied by individuals’ body dissatisfaction. Overall, there were several important findings from this study. First, weight-related self-monitoring is common among all college students; however, females and males engaged is somewhat different patterns of self-monitoring. Four distinct patterns of self-monitoring were identified among females: “no weight-related self-monitoring”, “all weight-related self-monitoring”, “knowing nutrition and calorie facts”, and “self-weighing only”. Among males, three patterns of self-monitoring were identified: “no weight-related self-monitoring”, “all weight-related self-monitoring”, and “all weight-related self-monitoring but calorie counting”. Females were more likely than males to be in the “all weight-related self-monitoring” class, while males were more likely than females to be in the “no weight-related self-monitoring” class. Furthermore, among females, any form of weight-related self-monitoring was associated with increased risk of all assessed measures of eating disorder risk compared to no self-monitoring, and engaging in all forms of weight-related self-monitoring was associated with the highest probability of all assessed measures of eating disorder risk.

However, calorie counting seemed to be the behavior that distinguished increased risk among males. Moreover, among both males and females, body dissatisfaction did not moderate these relationships.

Our findings align with previous research that documents that weight-related self-monitoring is common among young adults. The prevalence of self-weighing and calorie counting found in this study were similar to that found in other studies of college students.[25,36,76] Our findings build upon this previous research by examining additional forms of dietary self-monitoring (e.g. knowing nutrition facts and knowing calorie facts) not included in previous studies. In addition, we also examined how multiple forms of dietary self-monitoring and self-weighing are used in conjunction with one another, which has never been done prior. However, aligned with the findings of prior research, differences in use of weight-related self-monitoring were observed by BMI.[37,38] Differences in weight-related self-monitoring by BMI may be due in part to people of high BMI using self-monitoring to lose weight, as we know individuals of higher BMI are more likely to be trying to lose weight.[98]

As found in previous studies, self-weighing[23,29] and calorie counting[36,38] in the current sample were associated with increased risk among college students. By identifying patterns of weight-related self-monitoring behaviors, our work builds upon prior research focused on singular behaviors and examines the eating disorder risk associated with real-world patterns of use among college students. The study provides more accurate results of the relationship between weight-related self-monitoring and eating disorder risk by examining patterns of behaviors rather than singularly. Using latent class analysis allowed us to efficiently examine the patterns of use of weight-related self-monitoring while addressing the interrelated forms of self-monitoring and also acknowledging the distinctions. By using gender specific patterns of weight-related self-

monitoring, the present data is able to build upon prior research by examining gender specific patterns of weight-related self-monitoring and their associations with eating disorder risk. Though weight-related self-monitoring is more common in females than males, there were a significant proportion of men who were engaging in weight-related self-monitoring and those that were engaging in all forms had substantial eating disorder risk. These findings provide valuable insight into eating disorder risk factors for males, which are understudied. Our findings that body dissatisfaction does not moderate the relationship between weight-related self-monitoring and eating disorder risk indicate that weight-related self-monitoring may not exacerbate self-criticisms about one's body as suggested.[23]

The present study has several strengths including the large sample of students from multiple institutions. This large sample allowed us to identify patterns of weight-related self-monitoring use by gender and explore gender-specific relationships between weight-related self-monitoring and eating disorder risk. Having a sample from multiple institutions also ensures that our findings are not specific to a single institution, and thus increases the study's external validity. Further, we examined multiple forms of dietary self-monitoring, including forms of dietary self-monitoring that were prevalent but have never been explored to our knowledge. We also examined how different forms of weight-related self-monitoring are used in conjunction with one another and how those unique profiles of use impacted eating disorder risk. Our measure of eating disorder risk was another strength of the study, as the EDE-Q is a widely used and well validated measure.[92,93,95,99,100]

Despite the numerous strengths, the study is not without limitations. Single item measures were used to assess dietary self-monitoring. Moreover, we were unable to include other forms of weight-related self-monitoring such as tracking exercise as these behaviors were not assessed in

HBS. The study was also cross-sectional, and therefore we cannot establish causality. It may be that weight-related self-monitoring is a symptom or indicator of high eating disorder risk rather than causing increased risk for eating disorders, or there may have been unmeasured confounding factors such as perceiving one's self as overweight, perfectionism, internalization of the thin ideal and preoccupation with weight and/or shape and food. Additionally, response rates for HBS were low (19% and 27%), though comparable to other online survey response rates among college students.[101-103] In an attempt to correct for low response rate, we employed probability sampling weights during analysis. Due to a limited sample size and stratification in our analysis, we excluded gender minorities and therefore, our results do not represent all college students. Additionally, our results cannot be generalized to young adults who do not attend college.

The findings from the present study provide important information regarding what forms of weight-related self-monitoring college students are engaging in and how different patterns of monitoring are associated with eating disorder risk. Weight-related self-monitoring is common among this population, particularly dietary self-monitoring, and strategies are frequently used in conjunction with one another. Engaging in multiple forms of weight-related is associated with increased eating disorder risk, and body dissatisfaction does not moderate these relationships. Future research is needed to identify moderators of the relationship between weight-related self-monitoring and eating disorder risk, such as motivation for engaging in weight-related self-monitoring. It could be that those that choose to engage in weight-related self-monitoring to lose weight have increased risk compared to those who use weight-related self-monitoring because they were told to by their doctor for a medical reason that affects their dietary intake, for

example. Randomized controlled trials are needed to understand the extent to which weight-related self-monitoring causes increased eating disorder risk among college students.

There are several potential public health implications of the current study. This study found that people who engage in multiple forms of weight-related self-monitoring are a high-risk population. This finding may have implications for targeted screening and prevention efforts on college campuses. Prior research shows that online campus-wide screening, prevention, and treatment is effective to treat and prevent eating disorders.[104,105] By including measures of weight-related self-monitoring, college campuses could identify those at high-risk and use online resources to prevent or treat eating disorders. Therefore, the present study provides valuable information that could inform public health interventions on college campuses.

Table 2.1 Demographic characteristics of sample overall and by gender (n=10,010)

	Overall	Female (n=6,961)	Male (n=3,049)
	Weighted Prevalence (%)		
Race/Ethnicity			
White	66.9	67.5	66.2
Black or African American	4.4	4.6	4.3
Hispanic/Latinx	9.3	9.6	9.0
Asian	11.4	10.2	12.8
Other	7.9	8.1	7.7
Parent Education			
High school or less	10.1	10.1	10.0
Some college or Associate's degree	17.2	19.1	14.9
Bachelor's degree	30.3	30.0	30.6
Graduate degree	42.5	40.8	44.5
BMI Category			
<18.5	4.4	6.1	2.4
18.5-24.9	64.1	67.1	60.4
25-29.9	22.1	18.0	27.1
≥30.0	9.3	8.8	10.1
	Mean (Standard Error)		
BMI	24.0 (0.1)	23.6 (0.1)	24.6 (0.1)
Age (years)	23.9 (0.1)	23.7 (0.1)	24.4 (0.1)

Table 2.2 Prevalence of exposure, outcome, and moderator variables overall and by gender, weighted prevalence (%)

	Overall (n=10,010)	Female	Male	p-value
	Weight-related self-monitoring			
Knowing nutrition facts	44.1	44.8	43.3	0.24
Knowing calories	33.6	35.7	31.1	<.0001
Counting calories	12.8	14.8	10.4	<.0001
Self-weighing	32.7	30.9	34.9	0.0007
	Eating disorder risk			
EDE-Q ≥ 3	11.8	17.0	5.4	<.0001
Fasted	16.7	18.4	14.6	0.0001
Vomited	3.9	5.5	2.0	<.0001
Pills	3.4	4.2	2.4	0.0013
Laxatives	2.6	3.5	1.6	0.0003
Compulsive exercise	27.4	27.1	27.8	0.58
Binge eating	26.0	30.1	20.9	<.0001
	Moderator			
Body dissatisfaction	36.6	44.3	27.1	<.0001

Table 2.3 Model fit indices for weight-related self-monitoring latent class analysis among females

Seed	Number of classes	AIC	BIC
697982	2	201.32	262.96
	3	72.25	168.13
	4	38.90	169.01
	5	48.01	212.36
	6	58.00	256.59
930235	2	201.32	262.96
	3	163.24	259.11
	4	38.07	168.18
	5	48.05	212.41
	6	58.00	256.59
763239	2	201.32	262.96
	3	73.76	169.63
	4	38.04	168.15
	5	48.00	212.35
	6	58.00	256.59
674771	2	201.32	262.96
	3	163.07	258.94
	4	38.05	168.16
	5	48.04	212.39
	6	58.04	256.63
984387	2	201.32	262.96
	3	73.76	169.63
	4	38.05	168.16
	5	48.06	212.41
	6	58.06	256.66
579551	2	201.32	262.96
	3	163.07	258.95
	4	44.27	174.38
	5	48.00	212.35
	6	58.00	256.59
431461	2	201.32	262.96
	3	69.98	165.86
	4	**38.05**	**168.17**
	5	48.00	212.35
	6	58.00	256.59
680090	2	201.32	262.96
	3	69.98	165.86
	4	45.16	175.28
	5	48.90	213.25
	6	58.00	256.60
233320	2	201.32	262.96
	3	163.07	258.95
	4	45.33	175.44
	5	48.06	212.41
	6	58.00	256.59
495113	2	201.32	262.96
	3	69.98	165.86
	4	38.13	168.25
	5	48.04	212.40
	6	58.04	256.63

Seed = random seed for PROC LCA; BIC = Bayesian Information Criterion; AIC = Akaike's Information Criterion. Lower BIC and AIC values indicate better model fit.

Table 2.4 Model fit indices for weight-related self-monitoring latent class analysis among males

Seed	Number of classes	AIC	BIC
697982	2	93.19	147.39
	3	35.71	120.03
	4	38.01	152.44
	5	48.00	192.54
	6	58.00	232.65
930235	2	93.19	147.39
	3	35.71	120.03
	4	38.00	152.43
	5	48.00	192.54
	6	58.00	232.65
763239	2	93.19	147.39
	3	63.09	147.41
	4	38.00	152.43
	5	48.00	192.54
	6	58.00	232.65
674771	2	93.19	147.39
	3	68.16	152.48
	4	38.00	152.43
	5	48.00	192.54
	6	58.00	232.65
984387	2	93.19	147.39
	3	63.09	147.41
	4	38.00	152.43
	5	48.00	192.54
	6	58.00	232.65
579551	2	93.19	147.39
	3	35.71	120.03
	4	38.31	152.73
	5	48.00	192.54
	6	58.00	232.65
431461	2	93.19	147.39
	3	**35.71**	**120.03**
	4	38.00	152.43
	5	48.00	192.54
	6	58.00	232.65
680090	2	93.19	147.39
	3	35.71	120.03
	4	38.34	152.77
	5	48.07	192.61
	6	58.07	23.72
233320	2	93.19	147.39
	3	35.71	120.03
	4	38.35	152.78
	5	48.00	192.54
	6	58.00	232.65
495113	2	93.19	147.39
	3	35.71	120.03
	4	38.17	152.60
	5	48.00	192.54
	6	58.00	232.65

Seed = random seed for PROC LCA; BIC = Bayesian Information Criterion; AIC = Akaike's Information Criterion. Lower BIC and AIC values indicate better model fit.

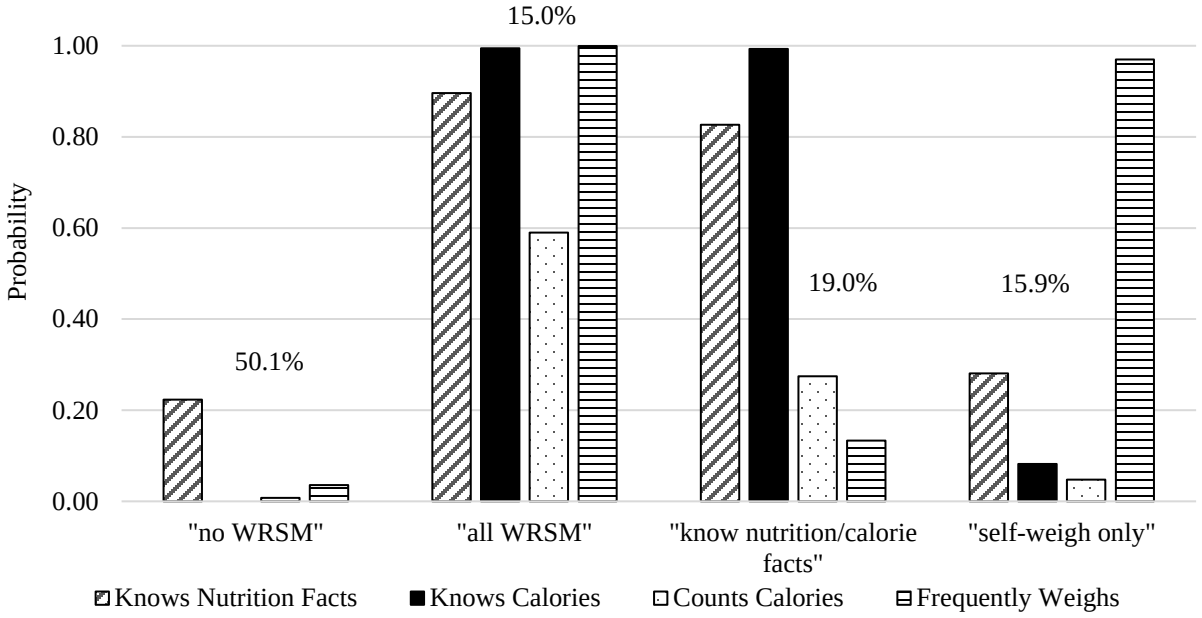

Figure 2.1 Probability estimates of each type of weight-related self-monitoring (WRSM) for each latent class for females

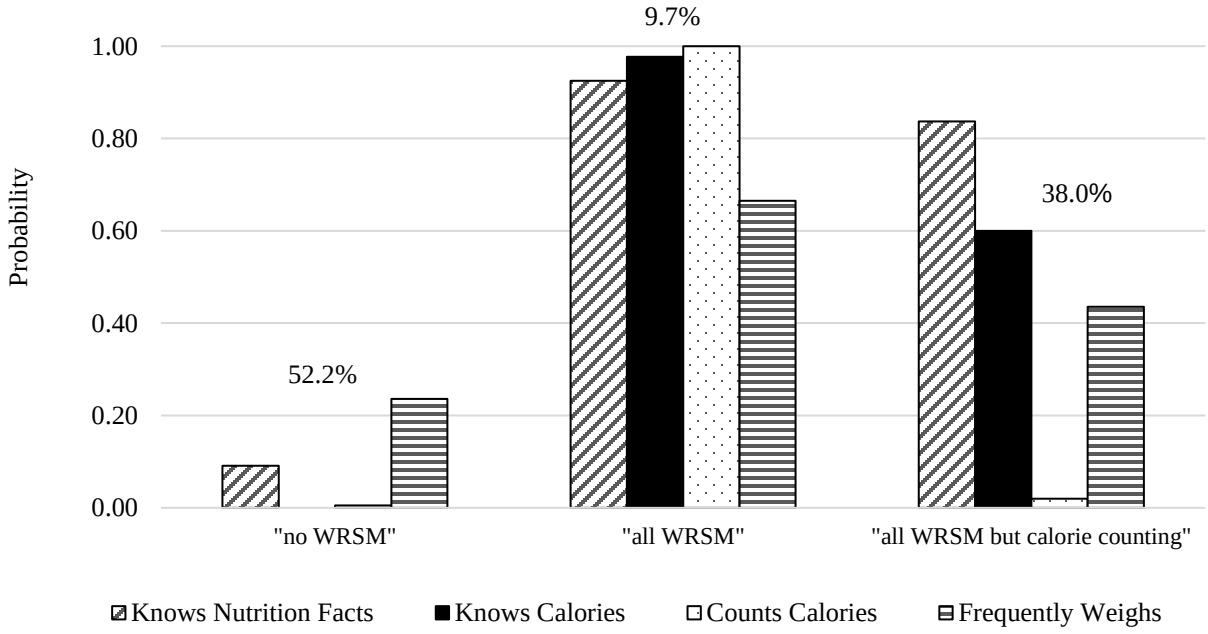

Figure 2.2 Probability estimates of each type of weight-related self-monitoring (WRSM) for each latent class for males

Table 2.5 Overall weighted prevalence and bivariate analyses between demographics and latent classes among females

Demographic	Overall	"No WRSM"	"all WRSM"	"Knowing nutrition/ calorie facts"	"Self-weighing only"	p-value
			Weighted Prevalence (%)			
Overall prevalence	.	50.1	15.0	19.0	15.9	
Race/Ethnicity						
White	67.5	66.7 [a]	70.6 [a]	68.9 [a]	65.6 [a]	0.0004
Black or African American	4.6	5.6 [a]	3.4 [a, b]	3.9 [a, b]	3.0 [b]	
Hispanic/Latina	9.6	9.7 [a]	7.7 [a]	10.4 [a]	10.3 [a]	
Asian	10.2	9.8 [a]	9.3 [a]	8.7 [a]	14.1 [b]	
Other	8.1	8.1 [a]	8.9 [a]	8.1 [a]	7.1 [a]	
Parent Education						0.85
High school or less	10.1	9.8	10.7	9.9	10.9	
Some college or Associate's degree	19.1	19.2	18.9	19.4	18.4	
Bachelor's degree	30.0	31.0	29.2	28.3	29.6	
Graduate degree	40.8	40.0	41.1	42.4	41.2	
BMI Category						<.0001
<18.5	6.1	8.1 [a]	4.6 [b]	3.5 [b]	4.4 [b]	
18.5-24.9	67.1	68.0 [a]	62.4 [b]	68.7 [a]	66.8 [a, b]	
25-29.9	18.0	15.8 [a]	21.5 [b]	20.2 [b]	19.2 [a, b]	
≥30.0	8.8	8.1 [a]	11.6 [b]	7.5 [a]	9.7 [a, b]	
			Mean (Standard Error)			
BMI, mean (SE)	23.6 (0.1)	23.3 (0.1) [a]	24.4 (0.2) [b]	23.8 (0.1) [c]	24.0 (0.1) [b, c]	<.0001
Age, mean (SE)	23.7 (0.1)	23.2 (0.1) [a]	24.6 (0.2) [b]	23.7 (0.2) [c]	24.4 (0.2) [b]	<.0001

*Superscripts are results of pairwise comparisons of proportions across latent classes within a row at p<.01; the same letter present at each prevalence indicates lack of statistical difference. WRSM = weight-related self-monitoring.

Table 2.6 Overall weighted prevalence and bivariate analyses between demographics and latent classes among males

Demographic	Overall	"no WRSM"	"all WRSM"	"all WRSM but calorie counting"	p-value
			Weighted Prevalence (%)		
Overall prevalence		52.2	9.7	38.0	
Race/Ethnicity					0.08
White	66.2	65.5 [a]	61.8 [a]	68.3 [a]	
Black or African American	4.3	5.2 [a]	3.4 [a]	3.3 [a]	
Hispanic/Latino	9.0	9.3 [a]	6.8 [a]	9.2 [a]	
Asian	12.8	12.9 [a]	18.6 [b]	11.2 [a]	
Other	7.7	7.2 [a]	9.4 [a]	8.0 [a]	
Parent Education					0.18
High school or less	10.0	9.0	13.6	10.4	
Some college or Associate's degree	14.9	14.3	13.5	16.1	
Bachelor's degree	30.6	32.1	32.0	28.2	
Graduate degree	44.5	44.6	40.9	45.2	
BMI Category					<.0001
<18.5	2.4	3.2 [a]	0.3 [a]	1.8 [a]	
18.5-24.9	60.4	65.0 [a]	46.6 [b]	57.7 [b]	
25-29.9	27.1	22.2 [a]	39.4 [b]	30.7 [c]	
≥30.0	10.1	9.6 [a]	13.8 [a]	9.8 [a]	
			Mean (Standard Error)		
BMI, mean (SE)	24.6 (0.1)	24.5 (0.1) [a]	25.8 (0.3) [b]	24.8 (0.1) [c]	<.0001
Age, mean (SE)	24.4 (0.1)	24.2 (0.1) [a]	24.5 (0.4) [a,b]	24.7 (0.2) [b]	.0037

*Superscripts are results of pairwise comparisons of proportions across latent classes within a row at p<.01; the same letter present at each prevalence indicates lack of statistical difference. WRSM = weight-related self-monitoring.

Table 2.7 Probability of eating disorder risk by weight-related self-monitoring (WRSM) pattern among females

	EDE-Q ≥ 3		Fasted		Vomited		Pills		Laxatives		Compulsive Exercise		Binge Eating	
	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted
"no WRSM"	7.6%[a]	7.6%[a]	12.1%[a]	12.1%[a]	2.8%[a]	2.8%[a]	1.9%[a]	1.9%[a]	1.2%[a]	1.2%[a]	18.8%[a]	18.8%[a]	22.1%[a]	22.1%[a]
"all WRSM"	39.9%[b]	39.9%[b]	32.1%[b]	32.0%[b]	13.4%[b]	13.4%[b]	9.1%[b]	9.1%[b]	10.3%[b]	10.3%[b]	45.6%[b]	45.4%[b]	45.4%[b]	45.3%[b]
"know nutr/cal facts"	22.6%[c]	22.8%[c]	20.8%[c]	20.9%[c]	6.9%[c]	7.0%[c]	5.7%[c]	5.7%[c]	3.6%[c]	3.5%[c]	32.4%[c]	32.5%[c]	35.2%[c]	35.2%[c]
"self-weigh only"	18.3%[c]	18.1%[d]	22.5%[c]	22.0%[c]	5.1%[c]	5.0%[c]	4.7%[c]	4.6%[c]	3.7%[c]	3.6%[c]	28.8%[c]	28.9%[c]	34.6%[c]	34.5%[c]

*Superscripts are results of pairwise comparisons obtained via Odds Ratios comparing within column probabilities at p<.01; the same letter present at each probability indicates lack of statistical difference. WRSM = weight-related self-monitoring. Adjusted models included age, BMI, parent education, and race/ethnicity as covariates.

Table 2.8 Odds ratios (99% confidence intervals) for body dissatisfaction moderation of relationship between weight-related self-monitoring (WRSM) and eating disorder risk among females

	Fasted	Vomited	Pills	Laxatives	Compulsive Exercise	Binge Eating
"no WRSM"	ref	ref	ref	ref	ref	ref
"all WRSM"	1.03[a] (0.83, 1.27)	1.09[a] (0.78, 1.53)	0.79[a] (0.56, 1.12)	0.83[a] (0.56, 1.21)	1.06[a] (0.89, 1.27)	0.87[a] (0.74, 1.12)
"know nutr/cal facts"	1.03[a] (0.84, 1.25)	0.93[a] (0.67, 1.31)	1.07[a] (0.72, 1.58)	0.90[a] (0.58, 1.41)	1.01[a] (0.86, 1.18)	1.11[a] (.95, 1.30)
"self-weigh only"	0.91[a] (0.74, 1.11)	0.85[a] (0.57, 1.26)	1.39[a] (0.88, 2.20)	1.33[a] (0.79, 2.26)	0.86[a] (0.73, 1.02)	0.95[a] (0.81, 1.12)

*Superscripts are results of pairwise comparisons obtained via Odds Ratios comparing within column probabilities at p<.01; the same letter present at each prevalence indicates lack of statistical difference. WRSM = weight-related self-monitoring. All models included age, BMI, parent education, and race/ethnicity as covariates.

Table 2.9 Probability of eating disorder risk by weight-related self-monitoring (WRSM) pattern among males

	EDE-Q ≥ 3		Fasted		Vomited		Pills		Laxatives		Compulsive Exercise		Binge Eating	
	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted
"no WRSM"	3.9%[a]	3.9%[a]	11.8%[a]	119%[a]	1.7%[a]	1.8%[a]	1.6%[a]	1.6%[a]	1.2%[a]	1.2%[a]	21.5%[a]	21.8%[a]	18.0%[a]	18.0%[a]
"all WRSM"	17.7%[b]	17.9%[b]	25.5%[b]	25.0%[b]	5.1%[b]	4.5%[a]	8.1%[b]	7.5%[b]	5.6%[b]	5.0%[b]	47.4%[b]	47.0%[b]	34.9%[b]	34.7%[b]
"all WRSM but count cals"	4.2%[a]	4.1%[a]	15.7%[a]	15.4%[a,b]	1.5%[a]	1.5%[a]	2.1%[a]	2.1%[a]	1.2%[a]	1.2%[a,b]	31.4%[c]	31.5%[c]	21.5%[a]	21.3%[a]

*Superscripts are results of pairwise comparisons obtained via Odds Ratios comparing within column probabilities at p<.01; the same letter present at each probability indicates lack of statistical difference. WRSM = weight-related self-monitoring. Adjusted models included age, BMI, parent education, and race/ethnicity as covariates.

Table 2.10 Odds ratios (95% confidence intervals) for body dissatisfaction moderation of relationship between weight-related self-monitoring (WRSM) and eating disorder risk among males

	Fasted	Vomited	Pills	Laxatives	Compulsive Exercise	Binge Eating
"no WRSM"	ref	ref	ref	ref	ref	ref
"all WRSM"	0.81[a] (0.59, 1.11)	1.33[a] (0.70, 2.54)	1.14[a] (0.60, 2.16)	0.85[a] (0.40, 1.80)	0.98[a] (0.75, 1.28)	1.11[a] (0.83, 1.48)
"all WRSM but calorie counting"	1.11[a] (0.87, 1.42)	1.14[a] (0.65, 2.03)	1.22[a] (0.68, 2.19)	1.34[a] (0.62, 2.93)	0.94[a] (0.76, 1.15)	0.90[a] (0.72, 1.12)

*Superscripts are results of pairwise comparisons obtained via Odds Ratios comparing within column probabilities at p<.01; the same letter present at each prevalence indicates lack of statistical difference. WRSM = weight-related self-monitoring. All models included age, BMI, parent education, and race/ethnicity as covariates.

Chapter 3 : Relationships Between Patterns of Technology-Based Weight-Related Self-Monitoring and Eating Disorder Behaviors Among College Freshmen

Introduction

The "quantified self", or using technology to monitor and manage health, is now the norm. From continuous glucose monitors that relay data to smart phones to application (app)-based mood journals to wearable devices that measure and report sleep duration and quality, many people today use technology to track some aspect of their health.[20] Using technology to monitor ones' weight, and the behaviors that contribute to weight, has become particularly common. New technologies, such as wearable fitness trackers, have increased the ease of weight-related self-monitoring, thereby popularizing the practice. For example, FitBit, a wearable device that tracks steps, is exceedingly popular with 27.4 million active users every month.[18] Further, apps like MyFitnessPal, which has 19 million active users every month[18] allows users to easily log their dietary intake (in addition to weight and physical activity) and quickly compare their intake to calorie and macronutrient goals.

Nearly all college students own a smartphone[106] and one in four young adults report using a health-based app on their smartphone.[20] Specific to using technology to monitor weight and weight-related behaviors, one recent study found 14% of college students report regularly using an app or device to calorie count and 20% use an app or device to track their physical activity.[36] Another study found that over 50% of college students used a physical activity self-monitoring device in the month prior to survey.[107] Taken together, it is clear that many college students are using technology for weight-related self-monitoring.

However, weight-related self-monitoring among college students may not be harmless. Of particular concern is whether this self-monitoring increases the risk of eating disorders and eating disorder behaviors among this population.[48,49] In a recent study of college students, 40% reported binge eating and 30% used a compensatory behavior such as compulsive exercise, vomiting, laxative or diuretic misuse, or using diet pills in the four weeks prior to being surveyed.[49] These behaviors were more common among undergraduate versus graduate students, and most prevalent among younger undergraduate students,[49] suggesting that early college may a period during which youth are at high risk for eating disorder behaviors. Preventing and treating these behaviors is of great public health importance given their known mental and physical health consequences including: decreased educational attainment[66] and classroom impairment,[67] increased likelihood of binge drinking,[68] substance abuse,[108] increased psychological distress over time,[65] gastrointestinal problems,[63] and other physiological problems.[62]

Weight-related self-monitoring can be a successful method of behavior change because it brings attention to and increase awareness of one's behavior.[3] However, this increased attention may be accompanied by increased self-criticism.[22,23] Such negative attention may increase the likelihood of using eating disorder behaviors to control body weight or shape. Moreover, there are similarities between the goals of weight-related self-monitoring and symptoms of eating disorders (e.g. increased attention to food and/or weight). Therefore, increased attention may transition into obsessional thinking leading to excessive or problematic use of eating disorder behaviors. To date, the relationship between weight-related self-monitoring and eating disorder behavior use has been understudied, particularly among college students. One area that needs more attention is the use of technology to engage in weight-related self-monitoring. Prior research on technology-based weight-related self-monitoring among college students found that

the use of calorie, but not fitness tracking apps was associated with binge eating and purging.[36] Within this study sample, two-thirds of those who used calorie tracking apps also used fitness tracking apps, and one tenth of the overall sample used both. However, the study did not examine whether use of multiple weight-related tracking acts simultaneously is indicative of greater eating disorder behavior versus the using weight-related tracking apps independently. Patterns of behaviors have been shown to have differential risk on mental health outcomes compared to singular behaviors, therefore, it is possible that the same would be observed among the relationships between weight-related self-monitoring and eating disorder risk.[47]

Those in early college are common users of technology-based weight-related self-monitoring and have a high likelihood of engaging in eating disorder behaviors. However, little is known about how technology-based weight-related self-monitoring may impact the likelihood of engaging in eating disorder behaviors. Therefore, the objective of the present study is to characterize how first-year college students use technology-based weight-related self-monitoring and identify associations between patterns of technology-based weight-related self-monitoring and eating disorder behaviors. The results from the present study could help inform how college campuses screen for eating disorders and their public health messaging regarding technology-based weight-related self-monitoring.

Methods

Participants

Data for the current study come from a web-based survey of first-year students at the University of Michigan designed to identify common weight control strategies used by college students. The survey was conducted in January 2017 and included first-year students, 18 years of age or older, at all University of Michigan campuses: Ann Arbor, Dearborn, and Flint.

Invitations to complete the survey were distributed via email by the Office of the Registrar at each campus to a random sample of 2,000 first-year students at the Ann Arbor campus, and all first-year students at the Dearborn and Flint campuses (approximately 1,000 and 600). The Ann Arbor campus had a response rate of 24.1%. Eight hundred and thirteen students initiated the survey. Participants who did not respond to at least 50% of the questions examined in this analysis were excluded as were individuals with missing data for exposure and outcome variables (n=158), resulting in 655 participants with sufficient data. BMI was calculated from self-reported height and weight, and students with biologically implausible height, weight, or BMI (n=4) were excluded from the analytic sample.[87-89] Students who identified as a gender other than male or female were also excluded from the analysis due to the inability to make valid inferences as a result of a small sample size (n=4). The final analytic sample size was 647 students. The research study was approved by the Institutional Review Board at the University of Michigan.

Measures

Weight-Related Self-Monitoring. Forms of weight-related self-monitoring included in the survey were identified from previously-conducted semi-structured interviews of weight-management, eating disorders, and/or physical activity professionals who work with adolescents. These professionals identified common technologies that the adolescents they work with use to self-monitor. In addition, an internet search was conducted to identify additional forms of technology-based weight-related self-monitoring. In the survey participants were first asked, “In the past year, have you used any apps or other technology, such as a Fitbit or MyFitnessPal, to monitor what you are eating, your exercise, or your weight?” If respondents answered “yes”, they were asked, “Please indicate which apps and/or technology you used in the past year and

how you used them (select all that apply)" with response options of: "Wearable fitness tracker (e.g. Fitbit, Jawbone, Garmin)", "Online or digital exercise log (e.g. MapMyRun, MyFitnessPal)", "Online or digital food log (e.g. MyFitnessPal, CalorieKing)", "Weight monitoring app/technology (e.g. iLostWhat or WIFI-connected scale)" and "An app or website for a specific diet or exercise plan (e.g. Kayla Itsines BBG, 21 day fix, etc.)". All forms of weight-related self-monitoring were included individually in the latent class analysis. Self-weighing was measured with the question, "How often do you weigh yourself?" with response options of: "Never", "Every month or less", "A few times per month", "Every week", "A few times per week", "Every day", and "More than once per day". To align with prior research for comparability as well as clinical guidelines, a positive response for the dichotomized variable included individuals who weighted themselves once per week or more.[9,90,91]

Eating Disorder Behaviors. Eating disorder behaviors were assessed using an overarching question, "How often have you done any of the following things in order to lose weight, keep from gaining weight, or change your body composition or shape during the past year?" The following behaviors were included: "Fasted (not eating for 24 hour or more)", "skipped meals", "took diet pills", "took laxatives", "took diuretics/water pills", "vomited after eating", "excessively exercised", and "used supplements or other products (protein powders, pre-workout, steroids, prescription drugs, ItWorks, waist trainers, etc.)". Response options included, "often", "sometimes", "rarely", and "never". Participants were categorized as using each of the behaviors if they indicated that they had used the behavior at least rarely. Diet pills, laxatives, diuretics, and vomiting were combined to a single variable purging outcome, all other eating disorder behaviors were examined independently.

Sociodemographics. Participants reported their height and weight, from which their body mass index (BMI) was calculated. To assess age, we used the question: “What is your age?”. Response options were: “18 years old”, “19 years old”, “20 years old”, “21 years old”, and “22 years old”. Due to the small sample of individuals 20-22 years old, we combined them into a single variable. Gender was assessed by the question, “What is your gender?” and response options of “Female”, “Male”, and “Other”; gender was then dichotomized. Race/ethnicity was assessed by the question, “What is your race/ethnicity? Select all that apply.” Response options included: “White”, “Hispanic or Latino”, “Black or African American”, “American Indian or Alaska Native”, “Asian/Pacific Islander”, “Middle Eastern/North African”, and “Other”. Any student who selected “Hispanic or Latino” were considered Hispanic/Latinx, all others who selected “Other”, more than one race/ethnicity, “American Indian or Alaska Native”, or “Middle Eastern/North American” were included in the “other” category of race/ethnicity. Highest parental education was assessed using two questions 1) “How far in school did your mother go? (Mark the highest level)” and 2) “How far in school did your father go? (Mark the highest level)”. For both questions, the response options were: “Did not finish high school”, “Finished high school or got GED”, “Did some college or training after high school”, “Finished College”, and “Advanced Degree (e.g. Master’s degree, MD, PhD, etc.)”. These two variables were combined to a single variable indicating the highest education level achieved by either parent. Parent education was condensed to high school or less, some college or training, bachelor’s degree, and graduate degree. BMI was assessed using self-reported height and weight which were assessed using two open-ended questions 1) “How much do you weigh in pounds?” And 2) “How tall are you?”, which had labels for them to answer in feet and inches. Calculated BMIs

were then categorized into the standard categories: less than 18.5, 18.5-24.9, 25-29.9, and 30 or above.

Statistical Analyses

All statistical analyses were performed using SAS 9.4 (Cary, NC). Gender-stratified analyses were conducted based upon a priori hypotheses that the relationships between weight-related self-monitoring and eating disorder risk would differ by gender.[107]

Descriptive Statistics. The distribution of responses to sociodemographic questions were examined for the total sample, and by gender. Univariate statistics as well as bivariate statistics by gender were computed for all methods of weight-related self-monitoring and eating disorder behaviors.

Latent Class Analysis. Latent class analysis (LCA) was used to identify profiles of weight-related self-monitoring. LCA is commonly used in health behavior[83-86] and eating disorder[77-82] research to categorize patterns of behaviors or characteristics using a person-centered approach.[109] All forms of weight-related self-monitoring assessed were included independently in the LCA. Because the seed used in PROC LCA[97] changes the results, for each gender, ten of the same randomly selected seeds were run for two through six classes. For every analysis, Akaike's Information Criterion (AIC) and Bayesian Information Criteria (BIC) and interpretability were used to select the best fitting models.[97] Seven of the models for women and 9 of the models for men had similar AIC and BIC. Therefore, these models were examined to determine if the latent classes had similar patterns of behaviors. Ultimately, the overall best model was selected using AIC, BIC, and interpretability.

Associations between LCA Classes and Participant Sociodemographics. After establishing the latent classes, sociodemographic characteristics of participants belonging to each

of those classes were examined. Chi-square, and Fisher's exact tests were used to test for differences in latent class membership by categorical sociodemographic variables and ANOVA was used to examine in mean BMI differed across the classes. Results for overall tests were considered statistically significant if $p<.05$. If significant, post hoc pairwise comparisons were conducted within rows to identify differences in the sociodemographic characteristics of members of each latent class. Post hoc pairwise comparisons were considered statistically significant at $p<.01$ to reduce the likelihood of type 1 error.

Associations between LCA Classes and Eating Disorder Behaviors. Unadjusted and adjusted logistic regression models were developed to assess the relationships between weight-related self-monitoring classes and eating disorder behaviors. Age, race/ethnicity, parental education and BMI were included in adjusted models because they are all known to be associated with eating disorder risk.[49,52,53,95,96] The predicted probabilities of eating disorder behaviors by latent class were calculated and pairwise comparisons conducted to identify differences in the probability of eating disorder behaviors between latent classes. Differences were determined to be statistically significant if $p<.01$.

Results

Description of the Study Sample

Approximately two thirds of the sample identified as female (68.9%) (Table 3.1). The sample was predominantly non-Hispanic White (66.0%), 5.0% identified as non-Hispanic Black or African American, 5.7% Hispanic/Latinx, 12.2% non-Hispanic Asian, and 11.1% another race or ethnicity. Nearly fifty percent of students had a parent with a graduate degree (49.2%), 32.8% had a parent with a bachelor's degree, 10.6% had a parent with some college or training, and 7.5% had parents with a high school degree or less. The average BMI was 23.4 (standard

deviation (SD) = 4.4); 5.1% had a BMI less than 18.5, 70.6% had a BMI between 18.5-24.9, 17.0% had a BMI between 25-29.9, and 7.3% had a BMI of 30 or above. Approximately two thirds of the sample were 18 years old (63.4%), 34.2% were 19 years old, and 2.5% were 20 or older.

Females were more likely than males to use an online fitness tracker (41.8% vs 20.5%, p<.0001) and online food journal (37.7% vs 16.0%, p<.0001) (Table 3.2). No gender differences were observed in the prevalence of using an app for a specific diet/exercise plan, using a wearable fitness tracker, self-weighing, or using a weight tracking app. Females were more likely to skip meals for weight loss than males (62.7% vs 48.5%, p=0.0007), and males were more likely than females to excessively exercise (61.6% vs 47.6%, p=.001) and use supplements (54.5% vs 20.7%, p<.0001).

Latent Class Analysis

Females. Using AIC, BIC, and interpretability, seed 763239 with three latent classes was deemed to be the best model (Table 3.3). The probability of each weight-related self-monitoring behavior by latent class can be found in Figure 3.1. Latent Class 1 was characterized by low probability of all forms of weight-related self-monitoring (identified as "no weight-related self-monitoring") and comprised 57.0% of the sample. Latent Class 2 was characterized by high probability of all forms of weight-related self-monitoring (identified as "all weight-related self-monitoring") and made up 15.2% of the sample. Latent Class 3 was characterized by high probability of using a wearable fitness tracker, an online fitness tracker, and an online food journal, but not using an app for a specific diet/exercise plan, frequently weighing, or using a weight tracking app (identified as "food and exercise self-monitoring"). This class comprised 28.0% of the sample.

Males. A model with three latent classes using seed 763239 was deemed superior based on AIC, BIC, and interpretability (Table 3.4). The probability of each form of weight-related self-monitoring by latent class can be found in Figure 3.2. Latent Class 1 was characterized by low probability of all forms of weight-related self-monitoring (identified as "no weight-related self-monitoring") and made up 78.6% of the sample. Latent class 2 was characterized by a high probability of all forms of weight-related self-monitoring (identified as "all weight-related self-monitoring") and made up 9.0% of the sample. Latent Class 3 was characterized by high probability of using a wearable fitness tracker and online fitness tracker, but not using an app for a specific diet/exercise plan, online food journals, frequently weighing, or using a weight tracking app (identified as "exercise self-monitoring") and made up 12.4% of the sample.

Bivariate Analysis of Latent Class and Sociodemographics

Females. There were differences in race/ethnicity by latent class (X^2=16.2, p=.04) (Table 3.5). However, none of the post hoc pairwise comparisons were significant. There were no differences in parent education or age by latent class. BMI differed by latent classes (mean: 23.4 p<.0001, categorical: p=.01). Females with a BMI between 18.5 and 24.9 were less likely to be in the "all weight-related self-monitoring" class (55.2% of individuals in the class) compared to the other two classes (72.0% in the "no weight-related self-monitoring" class and 71.2% in the "food and exercise self-monitoring" class). Those with a BMI of 30 or more were more likely to be in the "all weight-related self-monitoring" class (19.4%) compared to the "no weight-related self-monitoring" class (6.4%). Females in the "all weight-related self-monitoring" class had a higher BMI (mean=25.7, SD=5.5) than those in the "no weight-related self-monitoring" class (mean=22.7, SD=4.2) or the "food and exercise self-monitoring" class (mean=23.5, SD=4.6).

Males. Participant race/ethnicity, parent education, age, and BMI category did not differ across the latent classes (Table 3.6). Average BMI was higher among participants in the "all weight-related self-monitoring" class (mean=25.6, SD=6.3) compared to the "no weight-related self-monitoring" class (mean=23.0, SD=3.6).

Logistic Regressions and Probabilities

Females. Female participants in the "all weight-related self-monitoring" class had a higher predicted probability of fasting, skipping meals, excessively exercising, and using supplements compared to those in the "no weight-related self-monitoring" class (Table 3.7). There were no differences in the predicted probability of purging across classes. Participants in the "food and exercise self-monitoring" class also had higher predicted probability of fasting and excessive exercise compared to the "no weight-related self-monitoring" class.

Males. In unadjusted models, males in the "all weight-related self-monitoring" class were more likely to engage in purging and supplement use compared to males in the "no weight-related self-monitoring" class. However, in adjusted models, these differences became non-significant. Therefore, across all adjusted models, there were no differences in the probabilities of engaging in eating disorder behavior across latent classes among males. When examining effect estimates, there is a far greater predicted probability among those in the "all weight-related self-monitoring" class compared to the "no weight-related self-monitoring" class for all behaviors other than excessive exercise. Specifically, the adjusted predicted probability for fasting was 11.1% in the "no weight-related self-monitoring" class and 33.3% in the "all weight-related self-monitoring" class; the predicted probability of skipping meals was 46.0% in the "no weight-related self-monitoring" class and 72.2% in the "all weight-related self-monitoring" class; the predicted probability of purging was 8.5% in the "no weight-related self-monitoring"

class and 33.3% for the “all weight-related self-monitoring” class; predicted probability of supplement use was 50.6% in the “no weight-related self-monitoring” class and 88.9% in the “all weight-related self-monitoring” class.

Discussion

The objective of the study was to characterize the ways that college freshmen use technology-based weight-related self-monitoring and to examine the relationships between patterns of use and eating disorder behaviors. Technology-based weight-related self-monitoring tools were used with some frequency among first-year college students and the patterns of technology used differed by gender. For females, three classes were identified: “no weight-related self-monitoring”, “all weight-related self-monitoring”, and “food and exercise self-monitoring”. Among males, three classes were also identified: “no weight-related self-monitoring”, “all weight-related self-monitoring”, and “exercise self-monitoring”. Compared to males, a greater proportion of females were members of the “all weight-related self-monitoring” class. Further, among females, membership in the “all weight-related self-monitoring” was associated with increased predicted probabilities of fasting, skipping meals, excessive exercise, and supplement use compared to membership in the “no weight-related self-monitoring” class. Moreover, among females, engaging in food and exercise self-monitoring was associated with increased predicted probability of fasting and excessively exercising. No associations were observed between weight-related self-monitoring class and eating disorder behaviors among males. Despite the lack of statistical significance, perhaps due to small numbers of males engaging in weight-related self-monitoring, the pattern of effect estimates suggest that engaging in all forms of weight-related self-monitoring may be associated with increased probability of engaging in eating disorder behaviors.

Findings from the present study build upon prior studies of technology-based weight-related self-monitoring among college students. Similar to prior studies that have reported widespread use of apps or devices to count calories or physical activity.[36,107] We found that other technologies are also used by first-year college students including apps for specific diet/exercise plans (11.0%) and online fitness trackers (35.4%). Unlike studies that have examined use of specific weight-related self-monitoring behaviors, we examined how technology-based weight-related self-monitoring methods are used in combination by college students. This allowed us to more accurately characterize the ways in which college freshmen use technology for weight-related self-monitoring. Unlike prior research,[36] we found no association between technology-based weight-related self-monitoring and purging. This may be explained by the fact that the prior research looked at individual behaviors instead of patterns of behaviors.

We saw no statistically significant association between weight-related self-monitoring and eating disorder behaviors among males in our sample. However, we did find a pattern of differences in the predicted probability between the "no weight-related self-monitoring" and "all weight-related self-monitoring" classes, with higher predicted probability among the "all weight-related self-monitoring" class compared to the "no weight-related self-monitoring" class for fasting, skipping meals, purging, and supplement use. These results were not statistically significant, though it is likely that the lack of statistical association was likely due to insufficient sample size to detect differences. However, we were able to identify how males specifically used weight-related self-monitoring which will allow future research to examine other possible benefits and consequences of these patterns of behaviors in this population. Our use of gender stratified results adds to the somewhat sparse literature of eating disorder risk factors among males.[110]

Eating disorder behaviors are associated with a number of negative outcomes that are of particular relevance to colleges including educational attainment and impairment,[66,67] and binge drinking.[68] As such, colleges should prioritize identifying and addressing modifiable risk factors for eating disorder behaviors. The increased use of eating disorder behaviors among females who engage in multiple forms of technology-based weight related self-monitoring suggests that colleges should screen for weight-related self-monitoring as a means of identifying females at high risk for eating disorders. Screening efforts to identify students at increased risk for disordered eating may benefit from asking women whether they use technology-based method to monitor their eating, activity, and/or weight. Females that use weight-related self-monitoring could be given online prevention and treatment methods, which has been successful in the prevention and treatment of eating disorders.[104,105] Among men in this study, none of the patterns of technology-based weight-related self-monitoring were associated with increased risk of disordered eating. Given previous evidence that monitoring exercise may contribute to increased physical activity among men, self-monitoring of exercise appears to be a safe, and beneficial, behavior to support among men.[107] Exercise self-monitoring may therefore be suggested in public health interventions aimed at first-year college males to increase physical activity.[107]

This study has a number of strengths. First, by examining females and males separately, we were able to identify gender-specific patterns of technology-based weight-related self-monitoring and examine relationships weight-related self-monitoring patterns and eating disorder behaviors. We also had a sufficient sample size to examine males independently, which are a population that is understudied in eating disorders.[110] Moreover, we assessed technology-based weight-related self-monitoring methods that have not been previously studied such as using an app for a specific diet/exercise plan, and weight tracking apps. Additionally, we assessed

freshmen from three campuses instead of a single campus which may help increase generalizability of the study results.

However, the study is not without limitations. Single item measures were used to assess weight-related self-monitoring and eating disorder behaviors. Due to sample size and stratification in analysis, we were unable to assess these relationships in gender minorities, which are a population at high risk for disordered eating.[49] Our results also may also have limited generalizability given our limited response rate and because the study was conducted at a public university in the state of Michigan. Our response rate at the Ann Arbor campus was only 24.1%, though this is similar to other online surveys conducted among college students.[101-103] Additionally, we were not informed of how many students the survey was sent to at two of the campuses, and therefore, cannot calculate response rate for those campuses. The study was also cross-sectional, and thus the results cannot establish causality. It may be that eating disorder symptoms and technology-based weight-related self-monitoring co-occur among females due to a shared underlying cause such as preoccupation with food and weight. Alternatively, eating pathology may lead to an increase in weight-related self-monitoring among females. Future studies should assess temporality of weight-related self-monitoring and eating disorder behaviors to determine which behavior is initiated first. Longitudinal studies and randomized controlled trials are needed to establish whether using technology for weight-related self-monitoring causes eating disorder behavior among females.

The current study provides valuable information regarding what forms of technology-based weight-related self-monitoring are used by college freshmen, and how patterns of technology-based weight-related self-monitoring are associated with eating disorder behaviors. College freshmen commonly engage in technology-based weight-related self-monitoring, with

several using multiple methods together. Among females, engaging in multiple forms of technology-based weight-related self-monitoring may increase risk for eating disorder behavior. Among males, we did not find a statistical association but did see large effect estimates. While additional research is needed to determine the mechanisms underlying these relationships, colleges and universities may benefit from providing students who use multiple forms of technology-based weight-related self-monitoring access to eating disorder prevention programming.

Table 3.1. Sociodemographic characteristics of the study sample overall and by gender

	Overall (N=647)	**Females** (n=446)	**Males** (n=201)
	Prevalence, n (%)		
Race/Ethnicity			
White	427 (66.0%)	298 (66.8%)	129 (64.2%)
Black or African American	32 (5.0%)	22 (4.9%)	10 (5.0%)
Hispanic/Latino	37 (5.7%)	23 (5.2%)	14 (7.0%)
Asian	79 (12.2%)	57 (12.8%)	22 (11.0%)
Other	72 (11.1%)	46 (10.3%)	26 (12.9%)
Parent Education			
High school or less	48 (7.5%)	39 (8.8%)	9 (4.5%)
Some college or training	68 (10.6%)	48 (10.8%)	20 (10.1%)
Bachelor's degree	211 (32.8%)	144 (32.4%)	67 (33.7%)
Graduate degree	317 (49.2%)	214 (48.1%)	103 (51.8%)
BMI Category			
<18.5	33 (5.1%)	27 (6.1%)	6 (3.0%)
18.5-24.9	453 (70.6%)	306 (69.2%)	147 (73.5%)
25-29.9	109 (17.0%)	70 (15.8%)	39 (19.5%)
≥30.0	47 (7.3%)	39 (8.8%)	8 (4.0%)
Age			
18	410 (63.4%)	289 (64.8%)	121 (60.2%)
19	221 (34.2%)	146 (32.7%)	75 (37.3%)
20+	16 (2.5%)	11 (2.5%)	5 (2.5%)
	Mean (SD)		
BMI	23.3 (4.4)	23.4 (4.6)	23.3 (4.0)

Table 3.2 Prevalence of exposure and outcome variables overall and by gender

	Overall n (%)	**Female** n (%)	**Male** n (%)	**p-value**
Weight-related self-monitoring				
App for a Specific Diet/Exercise Plan	56 (11.0%)	41 (11.5%)	15 (9.9%)	0.59
Wearable Fitness Tracker	163 (28.2%)	118 (29.5%)	45 (25.3%)	0.30
Online Fitness Tracker	191 (35.4%)	158 (41.8%)	33 (20.5%)	<0.0001
Online Food Journal	167 (31.3%)	142 (37.7%)	25 (16.0%)	<0.0001
Frequently Weigh	132 (20.4%)	84 (18.9%)	48 (23.9%)	0.14
Weight Tracking app	32 (6.24%)	23 (6.4%)	9 (5.9%)	0.82
Eating disorder behaviors				
Fasted	99 (15.4%)	75 (16.9%)	24 (12.1%)	0.12
Skipped Meals	375 (58.3%)	279 (62.7%)	96 (48.5%)	0.0007
Purged	74 (11.5%)	55 (12.4%)	19 (9.6%)	0.31
Excessively Exercised	333 (52.0%)	211 (47.6%)	122 (61.6%)	0.001
Supplement Use	201 (31.2%)	92 (20.7%)	109 (54.5%)	<0.0001

Table 3.3 Model fit indices for weight-related self-monitoring latent class analysis among females

Seed	Number of classes	AIC	BIC
697982	2	73.44	126.74
	3	77.80	159.80
	4	77.45	188.15
	5	88.81	228.22
	6	96.51	264.62
930235	2	73.44	126.74
	3	73.28	155.28
	4	77.45	188.15
	5	88.81	228.22
	6	95.01	263.12
763239	2	73.44	126.74
	3	**73.28**	**155.29**
	4	77.45	188.15
	5	88.96	228.37
	6	97.33	265.44
674771	2	73.44	126.74
	3	73.28	155.28
	4	77.45	188.15
	5	87.79	227.20
	6	97.41	265.52
984387	2	73.44	126.74
	3	73.28	155.28
	4	77.45	188.15
	5	87.96	227.37
	6	101.22	269.33
579551	2	73.44	126.74
	3	73.28	155.28
	4	77.45	188.15
	5	84.52	223.93
	6	95.01	263.12
431461	2	73.44	126.74
	3	80.76	162.76
	4	77.45	188.15
	5	88.53	227.94
	6	97.41	265.52
680090	2	73.44	126.74
	3	73.28	155.28
	4	77.45	188.15
	5	88.81	228.22
	6	96.95	265.07
233320	2	73.44	126.74
	3	73.28	155.28
	4	77.45	188.15
	5	87.79	227.20
	6	98.89	267.01
495113	2	73.44	126.74
	3	77.80	159.80
	4	77.45	188.15
	5	84.52	223.93
	6	97.26	265.37

Table 3.4 Model fit indices for weight-related self-monitoring latent class analysis among males

Seed	Number of classes	AIC	BIC
697982	2	80.05	122.99
	3	75.02	141.09
	4	82.30	171.49
	5	91.32	203.63
	6	102.22	237.65
930235	2	80.05	122.99
	3	75.02	141.09
	4	82.30	171.49
	5	91.32	203.63
	6	102.22	237.65
763239	2	80.05	122.99
	3	**75.02**	**141.09**
	4	81.80	170.98
	5	89.47	201.79
	6	99.88	235.31
674771	2	80.05	122.99
	3	75.02	141.09
	4	82.21	171.40
	5	88.51	200.82
	6	101.11	236.54
984387	2	80.05	122.99
	3	75.02	141.09
	4	85.13	174.32
	5	89.86	202.17
	6	99.88	235.31
579551	2	80.05	122.99
	3	75.02	141.09
	4	82.21	171.40
	5	89.81	202.12
	6	102.62	238.06
431461	2	80.05	122.99
	3	79.12	145.19
	4	80.09	170.09
	5	89.96	202.17
	6	99.30	234.73
680090	2	80.05	122.99
	3	75.02	141.09
	4	80.09	170.09
	5	94.01	206.32
	6	99.88	235.31
233320	2	80.05	122.99
	3	75.02	141.09
	4	82.21	171.40
	5	88.51	200.82
	6	101.21	236.65
495113	2	80.05	122.99
	3	75.02	141.09
	4	82.30	171.49
	5	93.94	206.25
	6	101.42	236.86

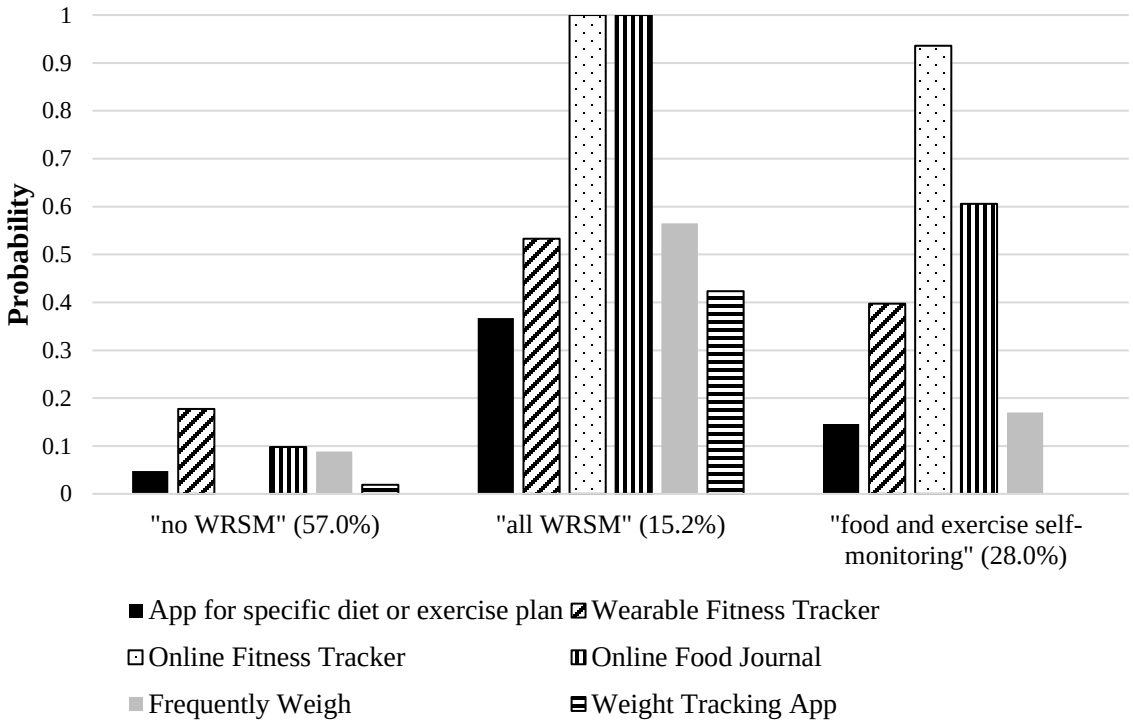

Figure 3.1 Probability estimates of each type of weight-related self-monitoring (WRSM) for each latent class for females. Percentages represent proportion of population that are categorized into that latent class.

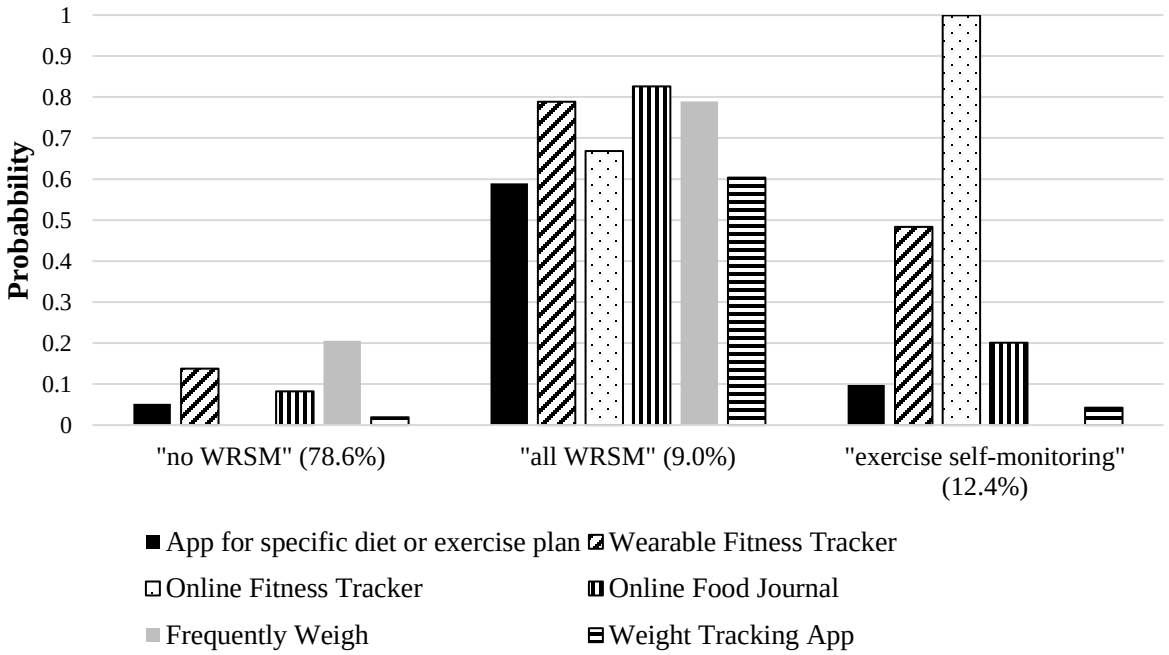

Figure 3.2 Probability estimates of each type of weight-related self-monitoring (WRSM) for each latent class for males. Percentages represent proportion of population that are categorized into that latent class.

Table 3.5 Overall prevalence and associations between sociodemographic characteristics and weight-related self-monitoring (WRSM) patterns among females

Demographic	Overall	"no WRSM"	"all WRSM"	"food and exercise self-monitoring	p-value
			n (%)		
Overall prevalence		254 (57.0)	67 (15.2)	125 (28.3)	
Race/Ethnicity					0.04
White	298 (66.8)	165 (65.0) [a]	40 (59.7) [a]	93 (74.4) [a]	
Black or African American	22 (4.9)	13 (5.1) [a]	1 (1.5) [a]	8 (6.4) [a]	
Hispanic/Latina	23 (5.2)	11 (4.3) [a]	8 (11.9) [a]	4 (3.2) [a]	
Asian	57 (12.8)	37 (14.6) [a]	8 (11.9) [a]	12 (9.6) [a]	
Other	46 (10.3)	28 (11.0) [a]	10 (14.9) [a]	8 (6.4) [a]	
Parent Education					0.45
High school or less	39 (8.8)	23 (9.1)	7 (10.5)	9 (7.2)	
Some college or training	48 (10.8)	31 (12.3)	3 (4.5)	14 (11.2)	
Bachelor's degree	144 (32.4)	82 (32.4)	26 (38.8)	36 (28.8)	
Graduate degree	214 (48.1)	117 (46.3)	31 (46.3)	66 (52.8)	
BMI Category					0.01
<18.5	27 (6.1)	18 (7.2) [a]	2 (3.0) [a]	7 (5.6) [a]	
18.5-24.9	306 (69.2)	180 (72.0) [a]	37 (55.2) [b]	89 (71.2) [a]	
25-29.9	70 (15.8)	36 (14.4) [a]	15 (22.4) [a]	19 (15.2) [a]	
≥30.0	39 (8.8)	16 (6.4) [a]	13 (19.4) [b]	10 (8.0) [a,b]	
Age					0.27
18	289 (64.8)	166 (65.4)	37 (55.2)	86 (68.8)	
19	146 (32.7)	80 (31.5)	29 (43.3)	37 (29.6)	
20+	11 (2.5)	8 (3.2)	1 (1.5)	2 (1.6)	
			Mean (SD)		
BMI	23.4 (4.6)	22.7 (4.2) [a]	25.7 (5.5) [b]	23.5 (4.6) [a]	<.0001

*Superscripts are results of pairwise comparisons of proportions across latent classes within a row at p<.01; the same letter present at each prevalence indicates lack of statistical difference. WRSM = weight-related self-monitoring.

Table 3.6 Overall prevalence and associations between sociodemographic characteristics and weight-related self-monitoring (WRSM) patterns among males

Demographic	Overall	"no WRSM"	"all WRSM"	"exercise self-monitoring"	p-value
			n (%)		
Overall prevalence		158 (78.6)	18 (9.0)	25 (12.4)	
Race/Ethnicity					0.59
White	129 (64.2)	103 (65.2)	9 (50.0)	17 (68.8)	
Black or African American	10 (5.0)	7 (4.3)	2 (11.1)	1 (4.0)	
Hispanic/Latino	14 (7.0)	9 (5.6)	3 (16.7)	2 (8.0)	
Asian	22 (11.0)	19 (12.0)	2 (11.1)	1 (4.0)	
Other	26 (12.9)	20 (12.7)	2 (11.1)	4 (16.0)	
Parent Education					0.72
High school or less	9 (4.5)	8 (5.1)	1 (5.6)	0 (0.0)	
Some college or training	20 (10.5)	14 (9.0)	3 (16.7)	3 (12.0)	
Bachelor's degree	67 (33.7)	53 (34.0)	7 (38.9)	7 (28.0)	
Graduate degree	103 (51.8)	81 (51.9)	7 (38.9)	15 (60.0)	
BMI Category					0.46
<18.5	6 (3.0)	6 (3.8)	0 (0.0)	0 (0.0)	
18.5-24.9	147 (73.5)	118 (75.2)	12 (66.7)	17 (68.0)	
25-29.9	39 (19.5)	28 (17.8)	4 (22.2)	7 (28.0)	
≥30.0	8 (4.0)	5 (3.2)	2 (11.1)	1 (4.0)	
Age					0.19
18	121 (60.2)	94 (59.5)	8 (44.4)	19 (76.0)	
19	75 (37.3)	60 (38.0)	10 (55.6)	5 (20.0)	
20+	5 (2.5)	4 (2.5)	0 (0.0)	1 (4.0)	
			Mean (SD)		
BMI	23.3 (4.0)	23.0 (3.6) [a]	25.6 (6.3) [b]	24.0 (3.6) [a, b]	0.02

*Superscripts are results of pairwise comparisons of proportions across latent classes within a row at p<.01; the same letter present at each prevalence indicates lack of statistical difference. WRSM = weight-related self-monitoring.

Table 3.7 Probability of eating disorder behavior by weight-related self-monitoring (WRSM) pattern among females

	Fasted		Skipped Meals		Purging		Excessive Exercise		Supplement Use	
	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted
"no WRSM"	10.7%[a]	10.9%[a]	55.3%[a]	54.8%[a]	10.6%[a]	10.4%[a]	36.0%[a]	35.1%[a]	15.0%[a]	15.3%[a]
"all WRSM"	31.8%[b]	31.7%[b]	82.1%[b]	82.1%[b]	19.7%[a]	19.6%[a]	74.2%[b]	74.3%[b]	36.4%[b]	36.4%[b]
"food and exercise self-monitoring"	21.6%[b]	21.6%[b]	67.2%[a,b]	67.2%[a,b]	12.0%[a]	12.0%[a]	57.3%[b]	57.3%[b]	24.0%[a,b]	24.0%[a,b]

*Superscripts are results of pairwise comparisons obtained via odds ratios comparing within column probabilities at p<.01; the same letter present at each prevalence indicates lack of statistical difference. WRSM = weight-related self-monitoring. Adjusted models included age, BMI, parent education, and race/ethnicity as covariates.

Table 3.8 Probability of eating disorder behavior by weight-related self-monitoring pattern (WRSM) among males

	Fasted		Skipped Meals		Purging		Excessive Exercise		Supplement Use	
	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted
"no WRSM"	11.0%[a]	11.1%[a]	46.5%[a]	46.0%[a]	8.4%[a]	8.5%[a]	60.9%[a]	60.6%[a]	51.0%[a]	50.6%[a]
"all WRSM"	33.3%[a]	33.3%[a]	72.2%[a]	72.2%[a]	33.3%[b]	33.3%[a]	64.7%[a]	65.6%[a]	88.9%[b]	88.9%[a]
"exercise self-monitoring"	4.0%[a]	4.0%[a]	44.0%[a]	44.0%[a]	---	---	64.0%[a]	64.0%[a]	52.0%[a]	52.0%[a]

*Superscripts are results of pairwise comparisons obtained via Odds Ratios comparing within column probabilities at p<.01; the same letter present at each prevalence indicates lack of statistical difference. WRSM = weight-related self-monitoring. Adjusted models included age, BMI, parent education, and race/ethnicity as covariates.

Chapter 4 : Effects of Introducing MyFitnessPal to Dietary Self-Monitoring Naïve Undergraduate Females: A Randomized Controlled Trial

Introduction

Eating disorders are a serious public health concern that can lead to suicidality, medical complications, and other psychiatric disorders.[50,51,61] One population in which eating disorders are of particularly prevalent is female college students; up to 13.5% of female college students have an eating disorder[75] and females are approximately four times more likely than males to suffer.[52,53] Sub-clinical eating disordered behaviors are also highly prevalent among female college students. One study of college females showed that within the four weeks prior to surveying, 49.1% of participants reported binge eating and 31.2% reported using a compensatory eating disorder behavior such as purging or compulsive exercise.[49] Eating disorders are preventable, however, and colleges are uniquely positioned to reach those at risk and implement prevention efforts.[69-74]

One proposed risk factor for eating disorders that has been the subject of much attention is weight-related self-monitoring. Weight-related self-monitoring involves tracking weight or behaviors that can affect weight such as food intake or exercise. Using smartphones apps to self-monitor weight and weight-related behaviors is increasingly common among the general population and among young adults in particular. An estimated 14-26% of college students use an app or device to count their calories,[36,111] and females are more likely than males to use calorie-tracking apps.[111] The popular weight-related self-monitoring app MyFitnessPal alone has amassed 165 million total users, including 19 million active users per month.[17,18]

While calorie counting is promoted in the context of supervised weight management programs,[9] and has been associated with weight loss in these samples,[112,113] calorie counting among the general population is of concern. Several studies have identified that counting calories often co-occurs with disordered eating behaviors.[36-38] In addition, among individuals seeking treatment for an eating disorder, 75% reported using MyFitnessPal to count calories and 73% of those who used MyFitnessPal to count calories believed the app contributed to their disorder.[34] However, there are several limitations inherent in these previous studies. First, retrospective reporting among people with eating disorders is subject to recall bias as well as confirmation bias, where individuals are more likely to report exposures that they believe caused their disorder and less likely to report exposures that they were not aware of or do not believe contributed. Second, all studies that have identified associations between calorie counting and eating disorder behaviors in this population are cross-sectional in design; they cannot determine whether calorie counting contributes to eating disorder risk, or if it is a behavior that comes secondary to a preoccupation with food and/or weight. While calorie counting may be a common, salient behavior among people with eating disorders, the calorie counting may not cause eating disorders. A randomized controlled trial is the only study design by which to determine if calorie counting causes increases in eating disorder risk as the study design balances both measured and unmeasured confounders.

To identify the effect of calorie counting on eating disorder risk among college females, the objective of this study was to design and implement a randomized controlled trial that assigned college females who had not engaged in calorie counting in the last year to use MyFitnessPal to count their caloric intake for approximately 30 days. Guided by previous research,[36-38] we hypothesized that females assigned to use MyFitnessPal for self-monitoring

dietary intake would report an increase in disordered eating symptoms immediately post-intervention relative to females assigned to the control condition. Study findings can inform public health and clinical recommendations regarding weight-related self-monitoring, and calorie counting specifically, among college females.

Pilot Study

First, a pilot study was designed to determine the feasibility of participant recruitment, adherence to tracking, and acceptability of tracking. Additionally the pilot study would provide information regarding eating disorder risk in the population and potential for change in eating disorder risk over time due to using MyFitnessPal for self-monitoring dietary intake to assist with estimating an effect size and determining an appropriate sample size for a fully powered trial. In this pilot study, participants were assigned to the intervention condition in which they were required to use MyFitnessPal to track dietary intake for 30 days or the control condition in which they were required to use Spendee, a financial planning app, to track money spent for 30 days.

Participants

The study consisted of 24 undergraduate females enrolled at the University of Michigan Ann Arbor campus. Participants were recruited via an email that was distributed to a randomly selected sample of 2,500 female undergraduate students during the Winter 2019 semester. The recruitment email (Appendix A) contained information about the study, which was advertised as a study examining how smartphone applications impact college students' well-being. The email included a link to a screening survey to determine eligibility. Of the 2,500 individuals sent a recruitment email, 491 (19.6%) completed the screening survey and 155 (31.6% of interested, 6.2% of overall sample) were eligible for study participation using the inclusion/exclusion

criteria described below. We enrolled the first 24 students that were eligible for the study based on recommendations to use 12 individuals per condition in pilot studies.[114] Of the 24 students who enrolled in the study, 23 provided post-intervention measurements. One participant was lost to follow-up in the intervention condition, resulting in a final analytic sample of 23 (11 intervention/12 control).

Inclusion/Exclusion Criteria

Participants were eligible for the study if, 1) they were female undergraduate students at the University of Michigan Ann Arbor campus, 2) had daily access to a smartphone, 3) would be willing to download and use an app for the study, 4) were fluent in English, and 5) were at least 18 years of age. Individuals were excluded if they had a self-reported history of any medical condition that impacts the type or amount of food eaten. Additionally, individuals who reported self-monitoring their dietary intake or finance tracking in the last year were excluded due to the potential that recent use might impact the effect of using the app. Participants who had a current or previous eating disorder diagnosis or an Eating Disorder Examination Questionnaire Short Form (EDE-QS) score ≥ 2, indicating high eating disorder risk, were also excluded to reduce the likelihood of participants experiencing severe adverse effects.

Procedure

Screening/Recruitment

Individuals who expressed interest in the study and were determined to be eligible based on the pre-screening survey were contacted by study staff via email or text message based on their preferred contact method. Participants were asked via email or text message to confirm the information they provided in the pre-screening survey including that they were over 18, female, an undergraduate student at the University of Michigan Ann Arbor campus, had regular access to

a smartphone and would be willing to download and use a smartphone app, had no condition that impacted the type or amount of food they ate, and that they never had an eating disorder. Eligible and interested individuals were then invited to come in for a first study visit.

Baseline Study Visit

The instructions for the study visit, including instructions provided to participants regarding their condition assignment are provided in Appendix C. At the beginning of the baseline study visit, participants provided written informed consent (Appendix B). The consent informed participants that the purpose of the study was to understand how the use of self-monitoring smart phone applications impact college student's well-being and that we hoped that the results of this study would help improve recommendations for using smart phone applications to improve health. After providing informed consent, participants completed a brief survey including the measures described below. Trained research staff then measured participants' heights and weights using a stationary stadiometer and scale. Height was recorded to the nearest tenth of a centimeter and weight was recorded to the nearest tenth of a pound. Participants were not shown or told their height or weight.

To determine which condition participants should be randomized to, research staff selected and opened a sealed envelope prior to the study participant's appointment in order to prepare usernames and passwords for the study visit. A total of 24 envelopes prepared, with equal proportions intervention and control. The intervention condition was the use of MyFitnessPal and the control condition was using Spendee, a finance tracking app. Use of Spendee was selected as the control condition to ensure that the calorie tracking portion of the self-monitoring was driving any observed effects, rather than self-monitoring in general. Both

intervention and control participants were instructed to use the app until their post-intervention visit, which was approximately 30 days after the baseline study visit.

After data collection was complete, participants randomized to the intervention condition were instructed to download MyFitnessPal on their smartphones. Research staff then requested permission to use the participants' smartphones to set up their MyFitnessPal account. Accounts were linked to the study email account and usernames, and passwords were randomly generated. Participants' daily caloric needs for weight maintenance were calculated using the Mifflin St. Jeor equation, which uses self-reported physical activity level, age, and measured height and weight. MyFitnessPal was set to send participants a daily reminder to track their food and drink at 10:30am. Participants were asked not to change any of the app settings, including the username and password, to not link MyFitnessPal to any other applications, and to only use MyFitnessPal to track their dietary intake. Participants were instructed to log everything they ate or drank on the app immediately after consuming it, starting the day after their baseline study visit and continuing until we saw them for the post-intervention study visit, approximately thirty days after the baseline study visit.

Participants in the control condition were instructed to download Spendee on their smartphones. After the app was downloaded, research staff requested the participants' phones to set up their accounts. Accounts were linked to the study email account with randomly generated usernames, and passwords. Researchers altered the settings so that the app would send participants a daily reminder to track their spending at 10:30am. Participants were instructed not to change the notification settings nor any other settings in the app. Participants were asked to track their spending starting the morning after their baseline study visit and continue until they

completed the post-intervention study visit, approximately thirty days after the baseline study visit.

For both experimental conditions, the post-intervention study visit was then scheduled for approximately thirty days following the baseline study visit and participants were compensated with a $25 gift card for their participation in the baseline study visit. Following the appointment, research staff sent participants a confirmation email for the post-intervention study visit with the same information as the appointment confirmation for the baseline study visit; emails to the participants also included a reminder to track in their respective apps starting the following day and until we saw them for the post-intervention study visit.

Post-Intervention Study Visit

In between the baseline and post-intervention study visits, participants received weekly surveys asking them to rank their compliance with the app for the week. Additionally, reminders for the post-intervention study visit were sent to participants three days before, and the day of, the post-intervention study visit. The follow-up study visit began with participants taking a survey that included measures of eating disorder risk and their experience using the apps. The survey took approximately twenty minutes to complete. Research staff then changed the password on the participant's app account so that they could no longer access their data.

All participants were then informed of the full purpose of the study and given a list of locally available mental health resources (Appendix D). At the end of the study visit, participants were given another $25 gift card as compensation for their participation in the post-intervention study visit.

Measures

The EDE-QS was used to assess eating disorder risk during participant screening, the baseline study visit, and the follow-up study visit. The EDE-QS has been shown to have reliability with the EDE-Q, the gold standard self-report measure of eating disorder risk, and assesses eating disorder behaviors and cognitions.[92,115] The EDE-QS was selected for participant screening because assesses behaviors and cognitions over the last week and has only 12 questions, whereas the original EDE-Q assesses the last 28 days and contains 28 questions. The score for the EDE-QS is determined by averaging the response options from all 12 questions. Response options range from 0 (0 days) to 3 (6-7 days). Individuals with an EDE-QS score ≥ 2 were deemed ineligible for study participation due to high likelihood of an eating disorder. This cut-off was selected based on the common use of 4 on the full-length EDE-Q as a marker of high eating disorder risk,[116,117] which has twice the number of response options as the EDE-QS, therefore, we halved the cut-off for high risk.

At the baseline visit, demographic variables were collected including race/ethnicity, parental education, and age. Race/ethnicity was assessed using the question, "What is your race/ethnicity? Select all that apply." Response options included: "Asian or Pacific Islander", "Black or African American", "Hispanic or Latino", "Native American or American Indian", "White", and "Other". All individuals who selected "Hispanic or Latino' were considered Hispanic/Latina, individuals who selected more than one race, or selected "Native American or American Indian" or "Other" were considered Other race/ethnicity. Parent education was assessed using the question, "Select the highest level of education achieved by a parent." Response options included: "Less than a high school education", "High school education or GED equivalent", "Some college", "Associates or other 2 year degree", "Bachelor's degree", and "Advanced degree (Master's degree or higher)". For analytic purposes, the categories were

condensed to: high school or less, some college or associate's degree, bachelor's degree, and graduate degree. Age was calculated using the day of their first study visit and their birthday which was ascertained using the question, "What is your birthday?". BMI was calculated using the measured height and weight, and categorized based on the standard less than 18.5, 18.5-24.9, 25-29.9 and 30 and above.

To determine adherence to the study conditions, at the post-intervention visit, participants were asked, "How often did you track in the app as was instructed to you at the first visit?" Response options included, "Never", "Sometimes", "About half the time", "Most of the time" and "Always". To assess acceptability of using the app, participants were also asked, "How much did you like using the app?". Seven response options were available and ranged from "like a great deal" to "dislike a great deal". Finally, after participants completed the post-intervention visit, research staff logged into their app accounts and counted the number of days in which they used the app to objectively determine adherence.

Statistical Analyses

Baseline descriptive statistics were calculated for the study sample. Univariate statistics were calculated for feasibility and acceptability measures. Finally, a standardized effect size (Cohen's d) was calculated for change in EDE-QS scores between baseline and post-intervention among intervention vs. control participants. SAS 9.4 (Cary, NC) was used for all statistical analyses.

Results and Discussion

Baseline descriptive statistics for the overall sample and by intervention condition can be found in Table 4.1. Overall, the sample was two-thirds White, 4.2% Hispanic/Latina, 16.7% Asian, and 12.5% identified as another race. Over half the sample had parents with a graduate

degree (58.3%), 16.7% had a bachelor's degree, 16.7% had some college degree or an associate's degree, and 8.3% had a high school education or less. The average BMI was 22.8 (standard deviation (SD) = 3.4), with 8.3% having a BMI less than 18.5, 70.8% having a BMI between 18.5-24.9, 16.7% having a BMI 25-29.9, and 4.2% having a BMI of 30 or greater. The average age was 20.6 years (SD = 1.2). The average baseline EDE-QS score was 0.32 (SD = 0.27), 8.3% of the sample reported fasting, 8.3% reported compulsively exercising, and 12.5% had binge eaten. No participants reported purging at baseline.

Fidelity measures indicated that MyFitnessPal was used an average of 26 days and Spendee was used an average of 13 days. A day was considered complete if there were 500 calories or more logged for the day. Over 90% of individuals using MyFitnessPal and all individuals assigned to use Spendee said that they tracked as instructed either most of the time or always. Exploring participants' data on MyFitnessPal and comparing it to the participants' self-ranked tracking accuracy and completeness on the weekly surveys between study visits, we surmised that participants were not able to accurately rank their fidelity on the weekly surveys. Additionally, 87% of all participants either liked their app or were neutral about it, indicating that it was acceptable to participants.

At baseline, the average EDE-QS was 0.31 (SD = 0.26) among those in the intervention condition and 0.33 (SD = 0.28) among those in the control condition. At the end of the study, the average EDE-QS was0.39 (SD = 0.34) in the intervention condition and 0.38 (SD = 0.25) in the control condition. To calculate Cohen's d, we used the change in EDE-QS scores for each intervention condition, which were 0.02 (SD = .16) for the control condition and 0.07 (SD = .14) for the intervention condition. From these values, a Cohen's d of 0.30 was calculated.

Conclusions

Based on this pilot study, the following modifications of the study protocol were made: Based on the low correlation between participant-reported compliance and objectively assessed compliance, we opted not to send participants weekly surveys between study visits for the fully powered study.

Second, after the completion of the pilot study, we reconsidered the ideal control condition to test the full effect of the intervention. We determined that using an app was part of the experience of using MyFitnessPal and therefore, using another app was not an optimal control condition. Thus, we elected the control condition for the fully powered study to be the absence of using MyFitnessPal. Thus, we modified our sample size calculation under the assumption that the control condition would have no change in eating disorder risk, instead of using the effect estimate as calculated using Spendee, and determined the effect size to be 0.45. Based on an α=.05, β=.80, and a Cohen's d of 0.45, the minimum sample size needed was 78 per condition. In order to detect a smaller effect of MyFitnessPal than calculated based on the assumption of no change in eating disorder risk in the control condition, a sample size of 100 participants per condition was used in the fully-powered trial.

Randomized Control Trial

Methods

Participants

Participants for the present study included 200 undergraduate females enrolled at the University of Michigan Ann Arbor Campus. Participants were recruited via an email that was distributed to a randomly selected sample of undergraduate students who identified as females and were enrolled in spring, summer, or fall classes in 2019. The recruitment email was sent to 2,101 randomly selected students in summer of 2019 with a follow-up recruitment email sent

approximately two weeks after the initial email. Another email was sent in the fall of 2019 to a randomly selected sample of 2,500 enrolled undergraduate females at the University of Michigan Ann Arbor campus who were not sent a recruitment email in the summer. The recruitment email (Appendix E) contained information about the study, which was advertised as an intervention examining how the use of smartphone applications impact college students' well-being. Individuals who were interested in participating in the study completed an online pre-screening survey that interested students completed to determine eligibility. The response rate for the screening-survey was 17.6%. There were 808 individuals who expressed interest in the study and 411 were eligible for study participation using the inclusion/exclusion criteria described below. Two hundred and one individuals completed baseline data collection and were randomized to intervention or control. One of these participants was excluded and replaced due to deviation from study protocol that invalidated her survey at the baseline study visit, and her envelope was replaced. Therefore, there were 100 individuals in the intervention condition and 100 individuals in the control condition. Eight participants were lost to follow-up between study visits, all of whom were in the intervention condition. The study's CONSORT diagram can be found as Figure 4.1.

Inclusion/Exclusion Criteria

Participants were eligible if they were undergraduate females at the University of Michigan Ann Arbor campus, had daily access to a smartphone, were fluent in English, and were at least 18 years of age. Individuals were excluded if they had a self-reported history of any medical condition that impacts the type or amount of food eaten because they may be used to self-monitoring aspects of their food consumption. Additionally, individuals who reported self-monitoring their dietary intake in the last year were excluded due to the potential that recent use

may impact the results. Participants who had a current or previous eating disorder diagnosis or an EDE-QS score ≥ 2, indicating high eating disorder risk were excluded to minimize potential for study participants experiencing serious adverse effects. The only difference in inclusion and criteria between the pilot and full study was that the use of a finance tracking app in the past year was no longer an exclusion criterion in the full study due to the change in control condition.

Procedure

Screening/Recruitment

Individuals who expressed interest in the study and were determined to be eligible based on the screening survey were contacted by study staff via email or text message based on their preferred contact method. Participants were asked via email or text message to confirm the information they provided in the screening survey including that they were over 18, female, an undergraduate student at the University of Michigan Ann Arbor campus, had regular access to a smartphone and would be willing to download and use a smartphone application if instructed to do so, had no condition that impacted the type or amount of food they ate, and that they never had an eating disorder. Interested individuals were then invited to come in for their baseline study visit.

Baseline Study Visit

After scheduling their appointment, participants were sent an email confirmation with their baseline study visit date, time, and location. Additionally, participants received reminders via text message or email three days before the first study visit and the day of. On the day of their study visit, participants were randomized to either intervention or control. Intervention was the use of MyFitnessPal for approximately 30 days, and the control condition was not using MyFitnessPal. To determine whether participants were intervention or control, research staff

selected and opened a sealed envelope. A total of 200 were envelopes prepared, with equal proportions intervention and control. Intervention condition was determined by study staff before the study visit in order to prepare an email and password when necessary.

Ultimately, 201 participants attended the baseline study visit. Participants provided written informed consent to participate in the study (Appendix F). The consent informed participants that the purpose of the study was to understand how the use of self-monitoring smart phone applications impact college student's well-being and that we hoped that the results of this study would help improve recommendations for using smart phone applications to improve health. After participants provided informed consent, they completed an online survey via REDCap. Once the survey was complete, research staff measured and recorded the participant's height and weight. Participants were not shown or told their height or weight.

The instructions provided to participants regarding their intervention condition is provided in Appendix G. Participants randomized to the intervention condition were instructed to download MyFitnessPal on their smartphones. Research staff then requested permission to use the participants' smartphones to set up their MyFitnessPal account. Accounts were linked to the study email account and usernames, and passwords were randomly generated. Participants daily caloric needs for weight maintenance were calculated using the Mifflin St. Jeor equation, which takes into account self-reported physical activity level, age calculated on birthday and date of study visit, and measured height and weight. MyFitnessPal was set to send participants a daily reminder to track at 10:30am. Participants were asked not to change any of the app settings, including the username and password, to not link MyFitnessPal to any other applications, and to only use MyFitnessPal to track their dietary intake. Participants were instructed to log everything they ate or drank on the app, immediately after consuming it starting day after the baseline study

visit and continuing until we saw them for the post-intervention study visit. The post-intervention study visit was then scheduled for approximately 30 days following the baseline study visit and participants were compensated a $25 gift card for their participation. Following the appointment, research staff sent participants a confirmation email for the post-intervention study visit with the same information as the appointment confirmation for the baseline study visit; emails to the participants in the intervention group also included a reminder to start using MyFitnessPal the following day and until they were seen for the post-intervention study visit.

Post-Intervention Study Visit

Reminders for the post-intervention study visit were sent to participants two weeks before, three days before, and the day of the post-intervention study visit. The second study visit began with participants taking an online survey via REDCap on a laboratory owned laptop with the same measures as the baseline visit, minus the demographic variables. The survey took approximately 20 minutes to complete. If the participants were randomized to the intervention condition, study staff changed the password on the participant's account so that they could no longer access the account and physically logged them out of the app on their phone to ensure that they could not alter the food logs. Weight was then measured for all participants.

Deception was used for the study description to provide an unbiased assessment of eating disorder risk. Participants were informed of the full purpose of the study at the end of the post-intervention study visit and given a list of locally available mental health resources (Appendix D). At the end of the study visit, participants were given another $25 gift card as compensation for their participation in the study. Individuals who attended baseline visit but not post-intervention study visits were contacted twice in an attempt to reschedule.

Measures

The measures remained unchanged from the pilot study. In the pre-screening survey, we assessed inclusion/exclusion criteria. At the baseline visit we assessed demographic characteristics including race/ethnicity, highest parent education, BMI (both continuous and categorical), age, and eating disorder risk as measured by the EDE-QS. At the post-intervention study visit we used the EDE-QS again to measure eating disorder risk. At both baseline and post-intervention study visits, the global score of the EDE-QS was used as our primary outcome as well as specific eating disorder behaviors, which were characterized on the EDE-QS as any use in the past 7 days (scoring 1-3 on the specific eating disorder behavior measures including fasting, purging, compulsively exercising and binge eating).

Statistical Analyses

All analyses were conducted using SAS 9.4 (Cary, NC). Results were considered statistically significant if $p<0.05$. Univariate and bivariate statistics were computed in total and by study condition for baseline characteristics including race/ethnicity, highest parental education, BMI, age, eating disorder behaviors, and EDE-QS global score. To account for missing post-intervention data, participants lost to follow-up had their baseline EDE-QS score imputed as their post-intervention score. To examine whether the intervention affected eating disorder risk, linear regression models were developed with post-intervention EDE-QS global score as the dependent variable and condition assignment as the independent variable, including baseline EDE-QS score as a covariate. For the secondary outcomes of fasting, purging, compulsive exercise, and binge eating, logistic regressions models including prevalence of each behavior as outcomes, condition assignment as predictor, and the prevalence of each behavior at baseline as a covariate were developed to calculate odds ratios with 95% confidence intervals. We did not impute values for secondary outcomes. Fidelity was determined by calculating the

proportion of days between baseline and post-intervention that individuals logged at least 500 calories.

Results

Descriptive statistics of the study sample can be found in Table 4.2. Approximately half of the participants identified as White (51.0%), 6.6% as Black or African American, 6.1% as Hispanic/Latina, 29.3% as Asian, and 7.1% as another race/ethnicity. Half (50.0%) of participants had a parent with a graduate degree, 25.0% had a parent with a bachelor's degree, 15.5% had a parent some college or associate's degree, and 9.5% had a parent with a high school education or less. The average BMI was 23.1 (SD = 4.8), and 8.0% had a BMI less than 18.5, 67.5% had a BMI 18.5-24.9, 16.5% had a BMI 25-29.9, and 8.0% had a BMI of 30 or above. The average age was 20.2 years (SD = 2.4) and the average EDE-QS global score was 0.45 (SD = 0.40). The prevalence of fasting, purging, compulsive exercise, and binge eating were 11.1%, 0.5%, 13.1%, and 10.1%, respectively.

The mean baseline and post-intervention EDE-QS scores by intervention condition can be seen in Figure 4.2 and Table 4.3. There was no association between intervention condition and change in EDE-QS score from baseline to post-intervention (β = -0.04, SE = 0.03). The intervention also did not affect the prevalence of fasting (OR=0.47, 95% CI: 0.12, 1.78), compulsive exercising (OR=0.61 95% CI: 0.25, 1.52), or binge eating (OR=1.51, 95% CI: 0.57, 4.01). No participants reported purging at the end of the study, therefore an odds ratio could not be computed.

On average, participants randomized to use MyFitnessPal used the app 89.1% of the days between study visits (SD = 0.17) and a median of 94.1% of days.

Discussion

The objective of the present study was to determine if introducing calorie counting via a popular app, MyFitnessPal, increased eating disorder risk among undergraduate females who had not recently monitored their dietary intake. In our highly-adherent sample, we did not see an effect of calorie counting using MyFitnessPal on EDE-QS global score or the prevalence of specific eating disorder behaviors. These results suggest that monitoring dietary intake and counting calories for one month does not increase risk of eating disorders in dietary self-monitoring naïve undergraduate females.

The findings of this study were counter to our hypothesis, which was based on cross-sectional studies that identified positive associations between calorie counting and eating disorder risk among college students.[36-38] This suggests that calorie counting is a component of or often occurs concurrently to eating disorder cognitions and behaviors, but that calorie counting by itself does not cause eating disorder cognitions and behaviors among the general population of college females. Therefore, while dietary self-monitoring could indicate high risk for an eating disorder, it may not be necessary to discourage dietary self-monitoring when used independently. Findings from chapters 2 and 3 indicate that dietary self-monitoring are often used in combination with one another. Therefore, our null results in the present study may be due to insufficient dose or exposure. Specifically, calorie counting may not be associated with eating disorder risk independently but there may be synergistic effects when used with other forms of weight-related self-monitoring. Further, research conducted among individuals participating in structured weight management programs, which include calorie counting, experience improved body image and self-esteem, indicating that calorie counting may be beneficial for some people in specific contexts.[118]

Research conducted among individuals with eating disorders who implicate MyFitnessPal in the development of their eating disorder[34,35] suggest that some individuals are more susceptible to the potential consequences of calorie counting. Therefore, an important future research direction is understanding whether there are some sub-populations among whom calorie counting is harmful. One trait may amplify susceptibility to disordered eating among those who engage in calorie counting is perfectionism. Individuals with perfectionism hold themselves to high standards and strive to meet those standards even at the costs of other factors in their lives.[119] These individuals may see their behaviors as right or wrong when tracking, and perfectionists have an increased concern for mistakes.[119] Therefore, individuals with perfectionistic traits may become exceedingly rigid about meeting weight-related self-monitoring goals, which may ultimately lead to obsessional thinking about food, exercise, or weight. Similarly, for individuals who are already at high risk for an eating disorder, the increased attention to food, exercise, or weight may exacerbate their pre-existing food or weight concerns.

The study had several strengths; most notably, the use of a randomized controlled trial design, which has never previously been used to understand the impacts of calorie counting in this population. Additionally, eating disorder risk was assessed using a validated scale.[115] However, this study also had limitations. Because the sample was limited to females at a single institution, results may not be generalizable to all college students. Additionally, the sample was purposefully low risk for an eating disorder; it is unknown if results would have been similar for individuals at high risk for eating disorders. We also had loss to follow-up exclusively in the intervention condition. However, we chose to impute their EDE-QS from their baseline to their post-intervention visit.

This study provides valuable information on the effects of calorie counting on eating disorder risk among undergraduate females. Although cross-sectional data shows a strong relationship between calorie counting and eating disorder risk, our findings demonstrate that calorie counting does not increase eating disorder risk among undergraduate females who do not tend to monitor their dietary intake. Thus, calorie counting may be an indicator of increased eating disorder risk, but does not itself directly increase eating disorder risk for this population broadly. Overall, a precision health lens may be warranted in further understanding for whom calorie counting is a neutral, beneficial, or harmful behavior.

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Table 4.1. Baseline characteristics of pilot study population overall and by intervention condition

	Overall	**Intervention** (n=12)	**Control** (n=12)
		N (%)	
Race/Ethnicity			
White	16 (66.7)	9 (75.0)	7 (58.3)
Black or African American	-	-	-
Hispanic/Latina	1 (4.2)	1 (8.3)	-
Asian	4 (16.7)	1 (8.3)	3 (25.0)
Other	3 (12.5)	1 (8.3)	2 (16.)
Parent Education			
High school or less	2 (8.3)	2 (16.7)	-
Some college or Associate's degree	4 (16.7)	3 (25.0)	1 (8.3)
Bachelor's degree	4 (16.7)	3 (25.0)	1 (8.3)
Graduate degree	14 (58.3)	4 (33.3)	10 (83.3)
Body Mass Index Category			
<18.5	2 (8.3)	1 (8.3)	1 (8.3)
18.5-24.9	17 (70.8)	7 (58.3)	10 (83.3)
25-29.9	4 (16.7)	3 (25.0)	1 (8.3)
≥30.0	1 (4.7)	1 (8.3)	-
Eating Disorder Behavior			
Fasted	2 (8.3)	1 (8.3)	1 (8.3)
Purge	-	-	-
Compulsive Exercise	2 (8.3)	1 (8.3)	1 (8.3)
Binge Eating	3 (12.5)	3 (25.0)	-
		Mean (Standard Deviation)	
Body Mass Index	22.8 (3.4)	23.4 (3.8)	22.3 (3.0)
Age (years)	20.6 (1.2)	20.8 (1.2)	20.4 (1.3)
EDE-QS Global Score	0.32 (0.27)	0.31 (0.26)	0.33 (0.28)

Table 4.2. Baseline characteristics of study population overall and by intervention condition

	Overall	**Intervention** (n=100)	**Control** (n=100)
		N (%)	
Race/Ethnicity			
White	101 (51.0)	49 (50.0)	52 (52.0)
Black or African American	13 (6.6)	6 (6.1)	7 (7.0)
Hispanic/Latina	12 (6.1)	6 (6.1)	6 (6.0)
Asian	58 (29.3)	30 (30.6)	28 (28.0)
Other	14 (7.1)	7 (7.1)	7 (7.0)
Parent Education			
High school or less	19 (9.5)	8 (8.0)	11 (11.0)
Some college or Associate's degree	31 (15.5)	15 (15.0)	16 (16.0)
Bachelor's degree	50 (25)	23 (23.0)	27 (27.0)
Graduate degree	100 (50.0)	54 (54.0)	46 (46.0)
Body Mass Index Category			
<18.5	16 (8.0)	9 (9.0)	7 (7.0)
18.5-24.9	135 (67.5)	73 (73.0)	62 (62.0)
25-29.9	33 (16.5)	12 (12.0)	21 (21.0)
≥30.0	16 (8.0)	6 (6.0)	10 (10.0)
Eating Disorder Behavior			
Fasted	22 (11.1)	11 (11.0)	11 (11.1)
Purge	1 (0.5)	0 (0.0)	1 (1.0)
Compulsive Exercise	26 (13.1)	8 (8.0)	18 (18.4)
Binge Eating	20 (10.1)	10 (10.0)	10 (10.1)
	Mean (Standard Deviation)		
Body Mass Index	23.1 (4.8)	22.6 (4.0)	23.6 (5.5)
Age (years)	20.2 (2.4)	20.4 (3.1)	20.0 (1.2)
EDE-QS Global Score	0.45 (0.40)	0.42 (0.37)	0.47 (0.42)

CONSORT Flow Diagraming

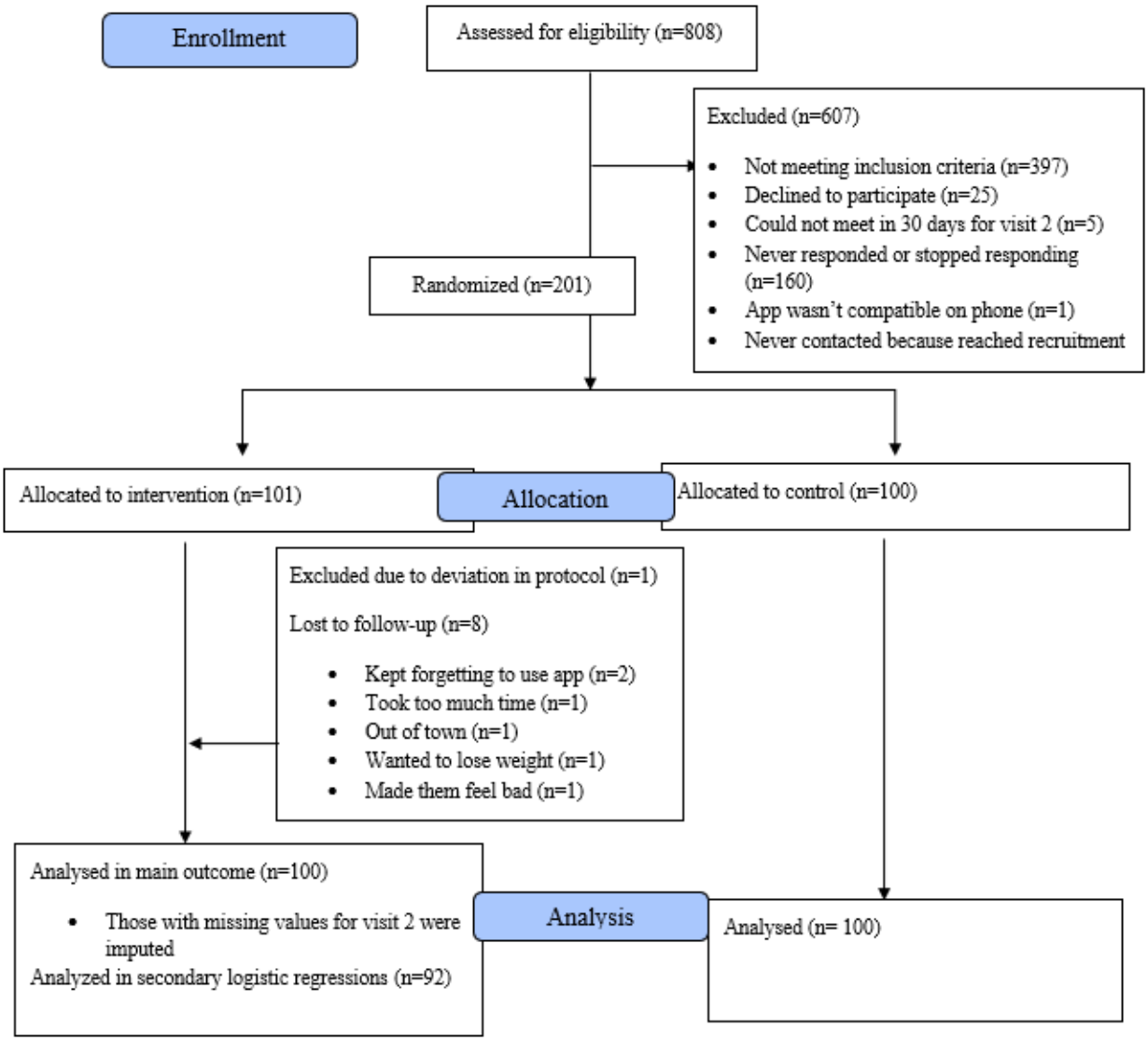

Figure 4.1 CONSORT Diagram

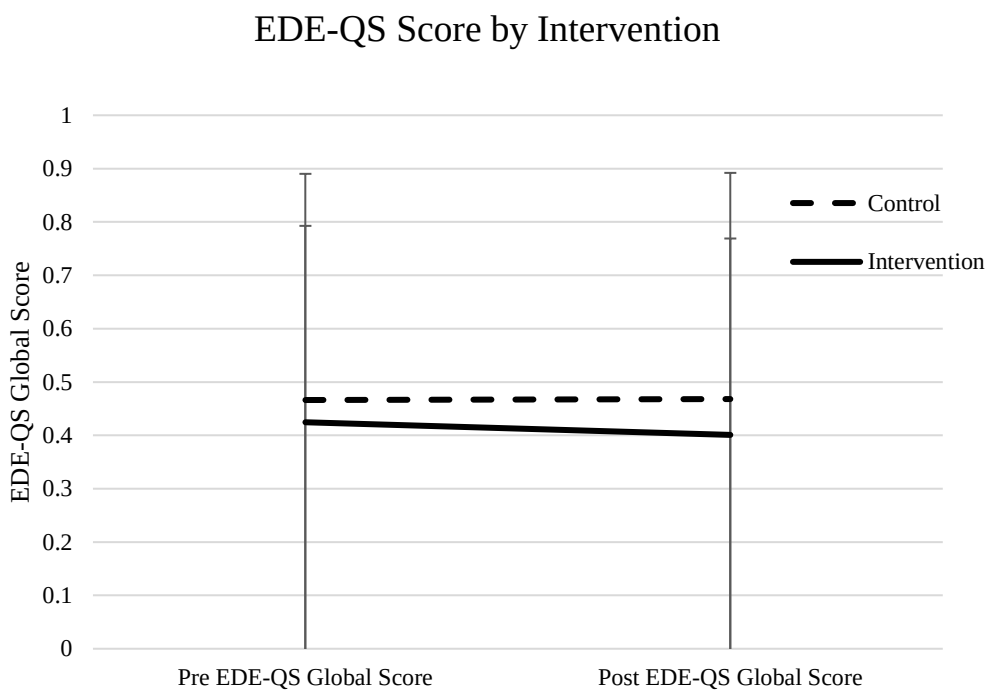

Figure 4.2. EDE-QS score over time by treatment group

Table 4.3. Effects of MyFitnessPal on Eating Disorder Risk

Primary Outcome: EDE-QS Score				
	Baseline Mean (SD)	**End of Study Mean (SD)**	**β (SE)**	**P-value**
Intervention	0.42 (0.37)	0.40 (0.31)	-0.04 (0.03)	0.22
Control	0.47 (0.42)	0.47 (0.40)		
Secondary Outcomes				
	Baseline Prevalence (%)	**End of Study Prevalence (%)**	**Odds Ratio**	**95% Confidence Interval**
Fasted			0.47	(0.12, 1.78)
Intervention	11 (11.0%)	4 (4.0%)		
Control	11 (11.1%)	9 (9.1%)		
Purge			---	---
Intervention	0 (0.0%)	0 (0.0%)		
Control	1 (1.0%)	0 (0.0%)		
Compulsive Exercise			0.61	(0.24, 1.52)
Intervention	8 (8.0%)	9 (9.9%)		
Control	18 (18.4%)	18 (18.0%)		
Binge Eating			1.51	(0.57, 4.01)
Intervention	10 (10.0%)	13 (14.1%)		
Control	10 (10.1%)	10 (10.2%)		

Chapter 5 : Conclusions

Summary of Main Findings

The overall purpose of this dissertation project was to examine whether weight-related self-monitoring was associated with eating disorder risk among college students. Specifically, we used a large epidemiological sample of undergraduate and graduate students to identify patterns of weight-related self-monitoring and examined whether identified patterns were associated with eating disorder risk and the extent to which body dissatisfaction moderated these relationships. Additionally, we identified patterns of technology-based weight-related self-monitoring among college freshmen and examined whether those identified patterns were associated with eating disorder behaviors. Moreover, using a randomized controlled trial we examined whether experimentally introducing digital dietary self-monitoring to a sample of undergraduate females increased eating disorder risk.

Associations between weight-related self-monitoring and eating disorder risk among undergraduate and graduate college students

In Chapter 2, we identified gender specific profiles of weight-related self-monitoring, including three forms of dietary self-monitoring and self-weighing, and examined their associations with eating disorder risk, as well as evaluated whether body dissatisfaction moderated these associations. Weight-related self-monitoring was common among all college students, with knowing nutrition facts and knowing calories in the food that one eats, a previously unstudied forms of dietary self-monitoring, being the most common. Among females, we identified four classes: “no weight-related self-monitoring”, “all weight-related self-

monitoring", "knowing nutrition/calorie facts", and "self-weighing only". The "no weight-related self-monitoring" class was characterized by low probability of all forms of weight-related self-monitoring and made up 50.1% of the sample of females. The "all weight-related self-monitoring" class was characterized by high probability of all forms of weight-related self-monitoring and constituted 15.0% of females. Nineteen percent fell into the "know nutrition/calorie facts" class which was characterized by high probability of knowing nutrition facts and calorie content, but low probability of self-weighing and counting calories. The "self-weigh only" class was characterized by high probability of self-weighing but low probability of all other weight-related self-monitoring behaviors and comprised 15.9% of females. Relative to the "no weight-related self-monitoring" class, all other patterns of self-monitoring were associated with increased eating disorder risk among females. Among males, we identified three classes: "no weight-related self-monitoring", "all weight-related self-monitoring", and "all weight-related self-monitoring but calorie counting". Similar to females, 52.2% of males fell into the "no weight-related self-monitoring" class, which was characterized by low probability of all forms of weight-related self-monitoring. Of males, 9.7% fell into the "all weight-related self-monitoring class", which was characterized by high probability of all forms of weight-related self-monitoring. The "all weight-related self-monitoring but calorie counting" was characterized by high probability of knowing nutrients, knowing calories, and self-weighing but not calorie counting. Over one third of males (38.0%) fell into the "all weight-related self-monitoring but calorie counting" class. Compared to the "no weight-related self-monitoring" class, increased risk for all measures of eating disorder risk, other than vomiting, was observed among the "all weight-related self-monitoring" class, but not the "all weight-related self-monitoring but calorie counting" class, suggesting that calorie counting is a differentiating marker for increased risk

among males. These findings align with prior research that show forms of weight-related self-monitoring often co-occur and that weight-related self-monitoring is associated with increased eating disorder risk.[36-38] Body dissatisfaction did not moderate these relationships for either gender. These results suggest that forms of weight-related self-monitoring are often used together, and that eating disorder risk may more accurately be captured using profiles of use, rather than singular behaviors.

Technology-based weight-related self-monitoring as a risk factor for eating disorder behaviors among college freshmen

In Chapter 3, we identified gender specific profiles of technology-based forms of weight-related self-monitoring and examined their associations with eating disorder behaviors. We assessed the following technology-based behaviors: An application (app) for a specific diet/exercise plan, wearable fitness tracker, online fitness tracker, online food journal, self-weighing, and using a weight tracking app. Similar to prior research, we found use of technology-based forms of weight-related self-monitoring to be common among students.[36,107] Among females we identified three classes: "no weight-related self-monitoring", "all weight-related self-monitoring", and "food and exercise self-monitoring". The "no weight-related self-monitoring" class was characterized by low probability of all assessed forms of weight-related self-monitoring and made up 57.0% of the sample. The "all weight-related self-monitoring" class was characterized by high probability of all assessed forms of weight-related self-monitoring and comprised 15.2% of the sample. The third class, "food and exercise self-monitoring" comprised 28.3% of the sample and had high probability of wearable fitness trackers, online fitness trackers, and online food journals and low probability of the other forms of weight-related self-monitoring. Those in the "all weight-related self-monitoring" class were more likely to report

fasting, skipping meals, excessively exercising, and using supplements compared to those in the "no weight-related self-monitoring class". Among males, three classes were identified: "no weight-related self-monitoring", "all weight-related self-monitoring" and "exercise self-monitoring". The "no weight-related self-monitoring" class was characterized by low probability of all assessed forms of weight-related self-monitoring and made up 78.6% of the sample. The "all weight-related self-monitoring" class was characterized by high probability of all assessed forms of weight-related self-monitoring and comprised 9.0%. The last identified class, "exercise self-monitoring" comprised 12.4% of the sample and was characterized by high probability of wearable and online fitness trackers and low probability of all other behaviors. There were no associations between technology-based weight-related self-monitoring and eating disorder behaviors among males. Prior research shows that using apps or devices for dietary and physical activity tracking is common college populations and that these two types of tracking are often done together,[36] but our findings also showed that other forms of technology-based weight-related self-monitoring such as using an app for a specific diet plan, using a weight tracking app, and self-weighing are also used in conjunction with these methods. These results suggest that technology-based forms of weight-related self-monitoring are used differently by females and males, and that females engaging in technology-based weight-related self-monitoring, particularly those engaging in all assessed forms of weight-related self-monitoring, have an increased eating disorder risk.

Experimentally introducing technology-based dietary self-monitoring does not increase eating disorder risk among undergraduate females

In Chapter 4, we examined whether introducing MyFitnessPal, an application used to track dietary intake, increased eating disorder risk using a randomized controlled trial. Based on

prior research that show cross-sectional associations between calorie counting and increased eating disorder risk,[36-38] we hypothesized that introducing MyFitnessPal would increase eating disorder risk among dietary self-monitoring naïve undergraduate females. However, we found that introducing MyFitnessPal to this population did not increase their eating disorder risk measured using the Eating Disorder Examination Questionnaire Short relative to controls. While calorie counting may be a component of or often occurs concurrently with eating disorder cognitions and behaviors, our findings indicate that calorie counting does not cause increased eating disorder cognitions and behaviors among the general population of college females who have not recently engaged in dietary self-monitoring.

Results in the Context of Weight-Related Self-Monitoring Literature

The present dissertation builds upon preexisting literature examining the potential benefits and consequences of weight-related self-monitoring. The cross-sectional findings of previous research have shown an association between calorie counting and physical activity self-monitoring and eating disorder risk.[36-38] However, these results examined singular behaviors, and our results from Chapter 2 and Chapter 3 indicate that these forms of weight-related self-monitoring are not often used in a singular nature. Thus, the results from prior research may be misleading as they indicate that these singular behaviors are causing increased risk whereas they may instead be incorrectly attributing the risk from certain patterns to behaviors that are part of the clustering of behaviors. However, our results from Chapter 4 indicate that introducing a singular behavior such as calorie counting may not increase eating disorder risk. Rather, it may be that engaging in multiple forms of weight-related self-monitoring is what increases eating disorder risk Additionally, prior research demonstrating that eating disorder patients believe that MyFitnessPal contributed to the development of their eating disorder may indicate that there are

certain sub-populations with unique characteristics that increased their risk.[34] Alternatively, the patients also may have been using more than one form of weight-related self-monitoring, as this was not assessed in the study. Furthermore, studies in which weight-related self-monitoring in the context of behavioral weight management is associated with increased body image. [118] It is unclear if this decreased risk is due to weight loss, social support associated with behavioral management, or if there is a causal mechanism. However, it does indicate that for some individuals weight-related self-monitoring may be beneficial. Therefore, our findings along with previous research indicate that there may be sub-populations for which weight-related self-monitoring is harmful, some for which it is neutral, and some for whom it may be beneficial, indicating an individualized approach to weight-related self-monitoring may be warranted.

Strengths and Limitations

This dissertation had a number of strengths. In Chapter 2 we used data from a large, multi-site epidemiology study of eating disorders. The use of data across multiple universities ensures that our results are more generalizable to college students throughout the United States. Moreover, by using multiple data sources throughout the dissertation we are able to gain a more comprehensive understanding of the relationships between weight-related self-monitoring and eating disorder risk among college students. Additionally, our gender stratified analyses in Chapters 2 and 3 was also a strength of the dissertation. Eating disorders among males are understudied and, by examining male specific patterns and how that impacted risk, this study made an important contribution to the literature on risk factors for eating disorders among males. Prior research suggests that calorie counting and physical activity tracking are often used together.[36] Building on this research, we used Latent Class Analysis to examine how these, as well as other unstudied forms of weight-related self-monitoring were used together. By

identifying profiles of use, we were able to more accurately examine the associations between how college students are engaging in weight-related self-monitoring and how that was associated with eating disorder risk. While the cross-sectional findings suggested a strong association between weight-related self-monitoring and eating disorder risk, cross-sectional studies cannot determine temporality or causality. Thus, we designed a randomized controlled trial, the first study of its kind, to examine possible causality.

Despite the strengths of this dissertation, there were several limitations. One such limitation is that the measurements of weight-related self-monitoring in Chapters 2 and 3 were single-item measures. Moreover, in Chapter 2, physical activity self-monitoring was not assessed. Because we know that physical activity self-monitoring is common among college students,[36,107] our latent classes may not represent the entirety of those students' weight-related self-monitoring behaviors. Additionally, the data analyzed in Chapters 2 and 3 was cross-sectional. As mentioned prior, cross-sectional data cannot establish causality. Therefore, it is possible that those that are already at high risk for eating disorders are self-selecting to engage in weight-related self-monitoring because of their preexisting preoccupation with food, exercise, and/or their body. This may explain why cross-sectional findings in Chapters 2 and 3 showed a strong relationship, but experimental results in Chapter 4 were null. In Chapter 4, we excluded males and also excluded from the study population undergraduate females with a preexisting high eating disorder risk (3.0% of individuals who expressed interest in the study). Additionally, we excluded those who had recently engaged in dietary self-monitoring (39.7% of individuals who expressed interest in the study). Therefore, our results from Chapter 4 are not generalizable to all college students.

Future Research

While the present dissertation provided valuable information on the relationships between weight-related self-monitoring and eating disorder risk, many research questions remain. The present research indicates that among self-monitoring naïve undergraduate females, introducing dietary self-monitoring did not increase risk of eating disorders. However, given the strong cross-sectional findings from Chapters 1 and 2, and that many individuals with an eating disorder attribute their eating disorder to dietary self-monitoring,[34,35] future work is needed to examine if there are sub-populations for which weight-related self-monitoring may be harmful or if the discrepancy between the cross-sectional randomized controlled trial findings is due to confounding factors such as shared underlying causes such as preoccupation with food and weight and/or shape, and other potential confounders as described in Chapter 1 and conceptual model (Figure 1.1). For example, those who are initially at high risk for an eating disorder may be more susceptible to becoming preoccupied with food, exercise, or weight when engaging in weight-related self-monitoring due to the combination of the increased attention brought to these factors by weight-related self-monitoring and preexisting weight or food concern. Similarly, individual characteristics associated with eating disorders, such as perfectionism, may also modify potential risks of weight-related self-monitoring. Elevated concern over mistakes and pursuing high personal standards are key constructs of perfectionism.[119] Engaging in weight-related self-monitoring may be particularly problematic for those with perfectionism due to a self-perception of their behaviors being right or wrong. Additionally, individuals who are perfectionists may become very rigid and obsessive about meeting their goals for dietary intake, physical activity, or weight due to their pursuit of high personal standards. The drive for perfectionism in this manner may then lead to an obsession with food, exercise, or their body and therefore increased eating disorder risk. Further, research should examine whether there is

differential risk based on motivation for engaging in weight-related self-monitoring. Dieting predicts increased likelihood for developing an eating disorder,[120] and it is possible that those engaging in weight-related self-monitoring for weight loss would be particularly susceptible to the potential risks associated with the use of weight-related self-monitoring. Similar research examining motivation for physical activity shows that there is differential eating disorder risk when weight loss is the motivation for physical activity, even when exercise is not excessive.[121,122] An online survey of college students assessing eating disorder risk, weight-related self-monitoring, and reason for weight-related self-monitoring could determine if motivation moderates the relationship. Additionally, because 39% of individuals interested in the study had recently engaged in dietary self-monitoring and were therefore excluded from the sample, we may want to do a similar trial among adolescents before they begin engaging in dietary self-monitoring and thus capturing the emergence of these behaviors in a vulnerable population.

Implications

Eating disorders are an important public health problem: their prevalence is high and increasing[75] and they are associated with a number of mental and physical health consequences that are of concern to college campuses ranging from worse educational outcomes[66,67] to increased mortality.[123] Because eating disorders are preventable diseases,[69-74] risk factors must be identified to inform public health interventions aimed at preventing and treating eating disorders on college campuses. The results from the present study indicate that college students who engage in weight-related self-monitoring are at increased risk for eating disorders. Identifying profiles of weight-related self-monitoring behaviors will allow for better detection of high-risk groups. Colleges offer a unique ability to screen for high-risk groups using easily distributed

campus wide online surveys. Screeners aimed at preventing and treating eating disorders could add questions pertaining to weight-related self-monitoring to increase ability to detect high risk individuals. For those that are identified as high risk, universities could then use online resources to prevent and treat eating disorders which has been successful in college communities in the past.[104,105]

In addition, there are also implications for clinical settings that serve college students. Clinics could begin asking about weight-related self-monitoring and connect students with local resources if they determine that the individual is high risk for an eating disorder. For students seeking weight management, it may also be important to take in the clinical context of the patient when determining whether or not to recommend weight-related self-monitoring. Structured behavioral weight loss programs using weight-related self-monitoring among adults have shown an increase in body satisfaction with weight loss.[118] However, if students are not engaging in such a regimented program for weight management but a clinician believes weight-related self-monitoring to be the best treatment option, it may be important from a clinical perspective to routinely assess eating disorder risk among the patient.

Overall, the results from this dissertation suggest that weight-related self-monitoring is associated with increased eating disorder risk but may not cause increased eating disorder risk among all college students. Identifying high risk groups on college campuses, both using online public health methods as well as clinical interventions, will allow for the prevention of eating disorders and eating disorder behaviors, thereby decreasing the risk for their associated deleterious mental and physical health outcomes.

Appendices

Appendix A : Recruitment Email for Pilot

Dear Students,

You are invited to participate in an important research study on the use of smartphone applications that track aspects of daily life, and how they impact well-being.

You may be eligible if you are:

1) At least 18 years old
2) Identify as Female gender
3) Have daily access to a smartphone

If you would like to participate, click here to complete a brief eligibility survey (link: https://redcapproduction.umms.med.umich.edu/surveys/?s=P4FWLDDEHK). It should take you approximately 5 minutes to complete. If you are eligible, we'll invite you to participate in 2 study visits and use an app for one month. You can receive up to $50 for participating.

If you have any questions or concerns, please contact Samantha Hahn at hahnsam@umich.edu.

Thank you for your consideration.

Sincerely,

Samantha Hahn

Appendix B : Consent for Pilot

Consent to be Part of a Research Study

Title of the Project: Tracking our Lives Study

Principal Investigator: Samantha Hahn, MPH, RD, Department of Nutritional Sciences, University of Michigan School of Public Health

Faculty Advisor: Kendrin Sonneville, ScD, RD, Department of Nutritional Sciences, University of Michigan School of Public Health

Co-investigator: Katherine Bauer, PhD, Department of Nutritional Sciences, University of Michigan School of Public Health

Co-investigator: Niko Kaciroti, PhD, Department of Biostatistics, University of Michigan School of Public Health

Co-investigator: Daniel Eisenberg, PhD, Department of Health Management and Policy, University of Michigan School of Public Health

Invitation to be Part of a Research Study

You are invited to participate in a research study. In order to participate, you must be a University of Michigan undergraduate student, identify as female, speak English fluently, be at least 18 years of age, and have daily access to a smart phone. In order to participate, you must not have any significant cognitive, psychosocial, or medical illness that would limit your ability to provide consent or participate in study procedures, have a medical diagnosis that affects your dietary intake, have a history of an eating disorder or currently have an eating disorder, and

cannot have tracked your daily spending or dietary intake in the last year. Taking part in this research project is voluntary.

What is the study about and why are we doing it?

The purpose of the study is to understand how the use of self-monitoring smart phone applications impact college student's well-being. The full purpose of the study cannot be revealed because we believe it may impact results. You will be informed of the purpose in its entirety at the end of your participation in the study. We hope that the results of this study will help improve recommendations on self-monitoring in the future.

What will happen if you take part in this study?

If you agree to take part in this study, you will complete a study visit today that will last approximately 1 hour and 15 minutes. You will fill out a survey and then you will download a specific smartphone application on your phone and will be instructed on how to use that smart phone application. You will be weighed and measured at the end of the visit today but will not be shown your height or weight. After today's visit, you will be asked to use a smartphone app daily for one month. After one month you will come back for a second study visit where you will again be asked to fill out a survey and will be weighed. This visit will last approximately 30 minutes. In between visits 1 and 2, you will be asked to answer a short survey once per week which we will send to you via email.

How could you benefit from this study?

We do not expect that you will significantly benefit from being in this study. Others might benefit because we hope that the findings from this study will help improve the recommendations for smartphone app use in the future.

What risks might result from being in this study?

There are some risks you might experience from being in this study. Some questions asked in the surveys may also make you feel uncomfortable. You may opt not to answer questions. Using the smartphone app may also make you feel uncomfortable. You can choose to stop using the app at any time; just tell the researcher you want to stop. Information will be available from researchers for psychological assistance should you desire that information.

How will we protect your information?

We plan to publish the results of this study. To protect your privacy, we will not include any information that could directly identify you.

There is a risk your information, such as your weight, may become known to other people which cause you discomfort. We will protect the confidentiality of your research records by storing your name separate from the data collected as part of the project. Research data will be stored on a password protected computer.

It is possible that other people may need to see the information we collect about you. These people work for the University of Michigan and government offices that are responsible for making sure the research is done safely and properly.

During data collection, researchers will not be accessing the contents of your smartphone app use. After the study is complete, researchers will change the password on the account so that you no longer have access to your account after the study.

What will happen to the information we collect about you after the study is over?

We will keep your research data to use for future research. Your name and other information that can directly identify you will be kept secure and stored separately from the research data collected as part of the project.

We may share your research data with other investigators without asking for your consent again, but it will not contain information that could directly identify you.

How will we compensate you for being part of the study?

To thank you for taking part in our study, you will be paid $25 at the end of visit 1, and $25 at the end of visit 2. Should you decide to withdraw from the study prior to the end of visit 1, you will not be compensated. If you withdraw from the study after visit 1 and before the completion of visit 2, you will receive a total of $25. Should you complete both visit 1 and visit 2, you will receive a total of $50.

Your Participation in this Study is Voluntary

It is totally up to you to decide to be in this research study. Participating in this study is voluntary. Even if you decide to be part of the study now, you may change your mind and stop at any time. You do not have to answer any questions you do not want to answer. If you decide to withdraw before this study is completed, data collected up to that point may be used in the study.

Contact Information for the Study Team and Questions about the Research

If you have questions about this research, you may contact:

Principal Investigator: Samantha Hahn, MPH, RD **Mailing Address:** SPH 1, 1415 Washington Heights, Ann Arbor, MI 48109 **Email:** hahnsam@umich.edu
Faculty Advisor: Kendrin Sonneville, ScD, RD **Mailing Address:** 3855 SPH I, 1415 Washington Heights, Ann Arbor, MI 48109 **Telephone:** (734) 763-8789 **Email:** kendrins@umich.edu

Your Consent

By signing this document, you are agreeing to be in this study. Make sure you understand what the study is about before you sign. I/We will give you a copy of this document for your records. I/We will keep a copy with the study records. If you have any questions about the study after you sign this document, you can contact the study team using the information provided above.

I understand what the study is about and my questions so far have been answered. I agree to take part in this study.

_____

Printed Subject Name

_____

Signature Date

Consent to Use Data for Future Research

I agree that my information may be shared with other researchers for future research studies that may be similar to this study or may be completely different. The information shared with other researchers will not include any information that can directly identify me. Researchers will not contact me for additional permission to use this information.

YES_____ NO_____

_____

Signature Date

Consent to be Contacted for Participation in Future Research

I give the researchers permission to keep my contact information and to contact me for future research projects.

YES_____ NO_____

_____

Signature Date

Appendix C : Protocol for Pilot

Protocol for Pilot Self-Monitoring Study

<u>Once Participants Completes Screening Questionnaire</u>

If participant is deemed eligible from pre-screening questions on survey distributed via REDCap, study staff will contact participants to confirm eligibility and to provide information about the study. If participant is deemed eligible and interested, they will be asked to schedule an in-person study visit in the North Ingalls Building at the University of Michigan in Ann Arbor.

If they selected phone call for their preferred method of contact

If participant doesn't answer, leave the following message: Hi *insert their name here*, this is Sam from the Tracking our Lives Study at the University of Michigan. I was hoping to give you more information about the study and to see if it sounds like something you are interested in participating in. Please give me a call back at (734) 274-9239. Thanks and have a great day!

Also send the same message via text.

If participant answers: Hi *insert their name here*, this is Sam from the Tracking our Lives Study at the University of Michigan. I was calling because you expressed interest in our study when we sent out an email through the Office of the Registrar, and I wanted to give you more information about our study. Is now a good time for that?

(If no) Okay, when would be a good time for us to give a call back? *[Set calendar reminder to call back]*

(If yes, re-ask screener questions besides EDE-Q). Great! I first have a few questions to confirm that you are eligible to participate.

1. How old are you? **if under 18, ineligible**

2. What is your academic standing? **if not an undergraduate, ineligible**
3. What is your gender? **if not female, ineligible**
4. Do you have daily access to a smartphone? **if no, then ineligible**
5. For this study, would you be willing to download and use an application on your smartphone? **if not yes, then ineligible**
6. In the past year have you used a smartphone app to track your spending?
7. In the past year have you recorded or kept track of what you've eaten?
8. Do you have any medical conditions that impact the types or amount of food that you eat? **if yes, then ineligible**
9. Do you currently, or have you ever been diagnosed with an eating disorder? **if yes, then ineligible**

(if ineligible) At this time, you are not eligible to participate in the study. Thank you for your time and interest.

(if eligible) Thank you, you are eligible to participate in our study. Participants in the study involves coming to our lab in North Ingalls Building on the University of Michigan Ann Arbor Campus for a study visit that will last about an hour and 15 minutes. During this visit, you will complete a questionnaire, have your height and weight measured, and be instructed on how to use a smartphone application. You will be compensated $25 for your time. You will be asked to use the application for one month and return for a second visit one month later. In between study visits you will be asked to complete a brief weekly survey. At the second study visit you will again have your height and weight measured and fill out another survey. At the end of study visit 2, you will be compensated an additional $25. Do you have any questions? *(Answer any questions).*

Are you interested in participating in the study? *(If yes, proceed with scheduling).*

(If no) Thank you for your time, I really appreciate you speaking with me. Have a great rest of your day.

(If yes) Okay, great. Let's set up a time for you to come in. Our office is located on North Ingalls Street, near the hospital. Can I email you the details for finding us?

We're scheduling visits on weekdays up until 7pm. Is there a day or time that works best for you? *(Pull up google calendar and schedule a time for Monday-Friday, 8:00 a.m. – 7:00 p.m. Be sure to check that there are no conflicts with others' schedules for NIB room 979).*

The email that I have on file is *insert email from screening survey*, is that correct?

(If incorrect, get email and update in REDCap)

(If correct) I will go ahead and send that email once we get off the phone. We also like to remind participants of their appointments a few days in advance. Would you prefer that we call, email, or text to remind you? *(Note preference in REDCap).*

Do you have any questions for me before we get off the phone today? *(Answer any questions).*

Great, thank you so much for your time and we look forward to seeing you on *insert appointment date and time*. Please don't hesitate to reach out if you have any questions.

Once off the phone, do the following:

1) Create an event on the study calendar with the following format: Participant # - Study Visit 1
2) Create an event on the calendar for the room
3) Send participant appointment confirmation email

If they selected text as their preferred method of contact

Hi, this is Sam from the Tracking our Lives Study at the University of Michigan. You expressed interest in our study when we sent out an email through the Office of the Registrar, and I wanted to give you more information about our study. Before that, I wanted to confirm a few details to make sure that you're still eligible for our study. Is that okay?

(if they respond no) Thank you for your time, have a great day. *mark as no longer interested in REDCap*

(if they respond yes) Great! First, what is your age, academic standing, and gender? **if under 18, not an undergraduate or not female, then ineligible**

Do you have daily access to a smartphone and if so, would you be willing to download and use an application on your smartphone for this study? **if don't have access or wouldn't be willing, then ineligible**

In the past year have you recorded or kept track of what you've eaten? **if yes, then ineligible**

In the past year have you used a smartphone app to track your spending? This can include tracking spending habits or budgeting but would not include checking your account balances. **if yes, then ineligible**

Do you have any medical conditions that impact the types or amount of food that you eat? **if yes, then ineligible**

Do you currently, or have you ever been diagnosed with an eating disorder? **if yes, then ineligible**

(if ineligible) At this time, you are not eligible to participate in the study. Thank you for your time and interest.

(if eligible) Thank you, you are eligible to participate in our study. Participation in the study involves coming to our lab in North Ingalls Building on the University of Michigan Ann Arbor

Campus for a study visit that will last about 45 minutes. During this visit, you will complete a questionnaire, have your height and weight measured, and be instructed on how to use a smartphone application. You will be compensated $25 for your time. You will be asked to use the application for one month and return for a second visit one month later. In between study visits you will be asked to complete a brief weekly survey. At the second study visit you will again have your weight taken and fill out another survey. At the end of study visit 2, you will be compensated an additional $25. Do you have any questions? *(Answer any questions).*

Are you interested in participating in the study? *(If yes, proceed with scheduling).*

(If no) Thank you for your time, I really appreciate you speaking with me. Have a great rest of your day.

(If yes) Okay, great. Let's set up a time for you to come in. Our office is located on North Ingalls Street, near the hospital. Can I email you the details for finding us?

We're scheduling visits on weekdays up until 7pm. Is there a day or time that works best for you? *(Pull up google calendar and schedule a time for Monday-Friday, 8:00 a.m. – 7:00 p.m. Be sure to check that there are no conflicts with others' schedules for NIB room 979).*

The email that I have on file is *insert email from screening survey*, is that correct?

(If incorrect, get email and update in REDCap)

(If correct) I will go ahead and send that email now. We also like to remind participants of their appointments a few days in advance. Would you prefer that we call, email, or text to remind you? *(Note preference in REDCap).*

Do you have any questions for me? *(Answer any questions).*

Great, thank you so much for your time and we look forward to seeing you on *insert appointment date and time*. Please don't hesitate to reach out if you have any questions to this phone number or my email, hahnsam@umich.edu.

Once appointment confirmed, do the following:

4) Create an event on the study calendar with the following format: Participant # - Study Visit 1
5) Create an event on the calendar for the room
6) Send participant appointment confirmation email

If their preferred contact method was email

Subject: Interest in Tracking our Lives Study

Hi *insert name here*,

My name is Sam from the Tracking our Lives Study at the University of Michigan. I was contacting you because you expressed interest in our study when we sent out an email through the Office of the Registrar, and I wanted to give you more information about our study.

In the survey that you filled out, you indicated that you were *insert age here*, an undergraduate student at the University of Michigan Ann Arbor, identify as female, have daily access to a smartphone and would be willing to download and use an application on your smartphone for this study, that you do not currently have any medical conditions that impact the types or amount of food that you eat, that you do not currently have or have ever had an eating disorder, that you haven't tracked what you've eaten in the last year, and that you haven't used a smartphone application to track your spending in the last year. Is this information correct?

Participation in the study involves coming to our lab in North Ingalls Building on the University of Michigan Ann Arbor Campus for a study visit that will last about 45 minutes. During this visit, you will complete a questionnaire, have your height and weight measured, and be instructed on how to use a smartphone application. You will be compensated $25 for your time. You will be asked to use the application for one month and return for a second visit one month later. In between study visits you will be asked to complete a brief weekly survey. At the second study visit you will again have your weight measured and fill out another survey. At the end of study visit 2, you will be compensated an additional $25.

If you are still interested in participating in our study please email me back with days and times that work best for you to come in for your first visit. We're scheduling visits on weekdays up until 7pm.

Additionally, if you have any questions please feel free to reach out.

Thank you,

Sam

(if email back that no longer interested note that in REDCap) Thank you for your time, have a great day.

(if email back that the info is correct and that they're interested in participating – update in REDCap and confirm appointment time).

Thank you so much, we look forward to seeing you on *insert appointment date and time*. We also like to remind participants of their appointments a few days in advance. Would you prefer that we call, email, or text to remind you? *(Note preference in REDCap).*

In the meantime, please don't hesitate to reach out if you have any questions to this email or my phone number, (734) 274-9239.

Thank you,

Sam

Once appointment confirmed, do the following:

1) Create an event on the study calendar with the following format: Participant # - Study Visit 1
2) Create an event on the calendar for the room
3) Send participant appointment confirmation email

Right after study visit is scheduled

Appointment Confirmation Email

Subject: Appointment Confirmation for Tracking our Lives study on *insert date of appointment* at *insert time of appointment*

Dear *insert name here*,

Thank you for participating in the Tracking our Lives Study. This email is to confirm that you have an appointment with us for *insert date and time* at the following location:

North Ingalls Building, 300 North Ingalls Street, Ann Arbor, MI 48109 (Click for a map).

A member of the research team will meet you in the lobby.

If you plan on driving, please plan to arrive 10-15 minutes before your scheduled appointment time to find parking. Both U-M Blue Busses and AATA busses have service stops near North Ingalls Building.

If you have any questions, or need to reschedule, please reply to this email or call us at (734) 274-9239.

Thank you,

Three business days prior to Study Visit 1

Send Appointment Reminder Email

Subject: Appointment Reminder for Tracking our Lives Study

Dear *insert name here*,

This is just a reminder that you have an appointment for the Tracking our Lives Study on *insert date and time here*. The study visit will be held at the following location:

North Ingalls Building, 300 North Ingalls Street, Ann Arbor, MI 48109 (Click for a map).

A member of the research team will meet you in the lobby.

If you plan on driving, please plan to arrive 10-15 minutes before your scheduled appointment time to find parking. Both U-M Blue Busses and AATA busses have service stops near North Ingalls Building.

If you have any questions, or need to reschedule, please reply to this email or call us at (734) 274-9239.

Thank you,

Reminder Text Message

Hi *insert name here*, this is a reminder that you have an appointment for the Tracking our Lives Study on *insert date and time here*.

The study visit will be held at North Ingalls Building, 300 North Ingalls Street, Ann Arbor. A member of the research team will meet you in the lobby.

If you have any questions, or need to reschedule, please call or text this number or email hahnsam@umich.edu. Thanks!

Reminder Phone Call

Hi *insert name here*, this is Sam from the Tracking our Lives Study. I was just calling to remind you that you have a study appointment scheduled for *insert date and time here* Does that still work for you?

(if no, reschedule and follow steps above)

(If yes) Great! The study visit will be at Room 979 of North Ingalls Building at 300 North Ingalls Street in Ann Arbor.

If you plan on driving, please plan to arrive 10-15 minutes before your scheduled appointment time to find parking. Both U-M Blue Busses and AATA busses have service stops near North Ingalls Building.

The appointment will last about an hour and fifteen minutes. If you have difficulty finding the room, please text or call this number. Someone will assist you in finding the lab.

Do you have any questions? *(if yes, answer questions).*

Great, we look forward to seeing you soon!

Day of Study Visit 1

Reminder text/call/email

Send a reminder text/call/email with the following message: Hi *insert name here*, this is Sam from the Tracking our Lives Study reminding you of your appointment today at *insert time* at North Ingalls Building. If you are running late, get lost, or need to cancel, please call (734) 274-9239 or email hahnsam@umich.edu. We look forward to seeing you today!

Randomization, preparing Smartphone Application Account

Randomly select one of the 24 sealed envelopes to determine which study arm the participant will belong to. Open the envelope to determine if the participant was randomized to MyFitnessPal or Spendee. Assemble a username and password for a Gmail account. The email should be the tolsXXX@gmail.com where XXX is a random number generated. The password is to be generated using a random password generator at https://passwordsgenerator.net/. For the password, do 8 character length with the following settings: exclude symbols, include numbers, include lowercase, include uppercase, exclude similar characters, exclude ambiguous characters, generate on your device, do not auto-select and do not save my preferences. Make sure that the username is available on the representative application that has been chosen. Create a document for the participant that indicates the application username and password. Record this information in REDCap.

Assemble Study Folder

Assemble the participant folder with the following documents:

- Consent form
- Visit 1 questionnaire*
- Anthropometrics form
- Gift card
- Laptop

*the survey will be administered via REDCap on the laptop, but if there are any issues, research staff will administer by hand.

Be sure that the laptop is charged.

Fill out Study Visit 1 HSIP Section on REDCap

Fill out the Visit 1 HSIP section on REDCap with information about the HSIP number and gift card number.

Determine Approximately When Visit 2 Should Occur

Determine what date is 30 days after visit 1, and therefore, when visit 2 should occur. Record what days fall within the 30-35 day window in the study folder.

Gather Study Visit Materials

- Folder
- Laptop
- Two pencils
- Do not disturb sign

Table A.1 Pilot Study Visit 1 Timeline

Time	**Activity**
10 minutes	Review study consent and obtain participant consent
20 minutes	Participants complete Visit 1 Questionnaire
5 minutes	Participants' height and weight measured
20 minutes	Participants download and are instructed on how to use application
5 minutes	Schedule next visit
5 minutes	HSIP Payment

Study Visit Outline

Put the materials for the study visit in the room. Go to the lobby of 300 N Ingalls Building 10 minutes before the scheduled meeting time and escort them to the study room.

Consent

Sit across the table from the participant and give her a copy of the informed consent. Have the participant sign both copies of the informed consent, and sign both copies yourself – one copy is given to the mother and the other copy is kept for study records.

Visit 1 Questionnaire

Using the laptop login to REDCap and confirm that you have the correct Study ID for the REDCap forms. If REDCap isn't working, use the paper copy of the Visit 1 Questionnaire. Open the questionnaire in survey form and put the laptop in front of the participant.

Allow participants to complete the questionnaire on their own.

Anthropometry Protocol

Tell participants, "Now I'm going to measure your height and weight."

- Use figure 1 for reference
- Place the measuring board against a hard, flat surface, making sure the board is stable.
- Have participant remove shoes, bulky, outer clothing, hats, and any buns, braids, hair ornaments, or jewelry from the top of the head (based on willingness of the Participant).
- Place the questionnaire and pencil on the floor or ground and stand on the left side of the person.
- If you cannot do above, find the best scenario, and take notes of any deviations from the protocol and the reason why.
- Position the participant and explain procedures out loud.

- Ask participant to stand on the base of the height measuring board and face forward. Gently guide them onto the board and instruct them to back up until a part of their body touches the board (buttocks or shoulders).
- Help Participant place their knees and feet in the correct position, with knees and feet either together or apart. Instruct them to bring their legs together until their knees or feet touch. There are three possible positions for knees and feet (whichever touches first!)
    - Knees together, feet together
    - Knees together, feet apart
    - Knees apart, feet together
- Determine if the participant's feet should be against or away from the back of the height board by observing the imaginary line drawn from the tip of the shoulder to the heel, which is called the "mid-axillary line" (arrow 3). This line should be perpendicular (i.e. 90 degrees) to the base of the height board where the person is standing. Note that with almost all adults, you will have to move the person's feet away from the back of the height board to put them in the proper position (arrow 4).
- Ask the person to look straight ahead. Place your left hand on the person's chin and gradually close your hand (into a U) (arrow 5). Position the person's head so that the line of sight (i.e. the Frankfort Plane) is parallel to the ground or perpendicular (i.e. 90 degrees) to the back of the measuring board (arrow 6). Note that with most adults, the back of the head will not touch the back of the height board – there will be space between the back of the person's head and the back of the height board (arrow 7).

- After you have placed the person's head in the proper position, release your hand from the person's chin and ask her to hold her head in the position you have just placed it. Check from the front that the head is straight from the front. Adjust if needed.
- Make sure the person's shoulders are level (arrow 8), the hands are at the person's sides (arrow 9) and at least the buttocks touch the back of the board. Note that with most all adults, only the buttocks and perhaps the shoulder blades will touch the back of the measuring board (arrows 10 and 11).
- Check positioning: stand at a 45-degree angle to the measurement board and check to make sure the participant is in the proper position without moving away from the stadiometer.
- Lower the stadiometer head piece: When the Participant's position is correct, lower the headpiece on top of the head (arrow 12) making sure to push through the person's hair. Read and call out the measurement to the nearest 0.1 cm. Raise the headpiece away from the person's head and escort the person off the height board while repeating the measurement in a low audible voice.
- Record the measurement legibly and erase any errors.

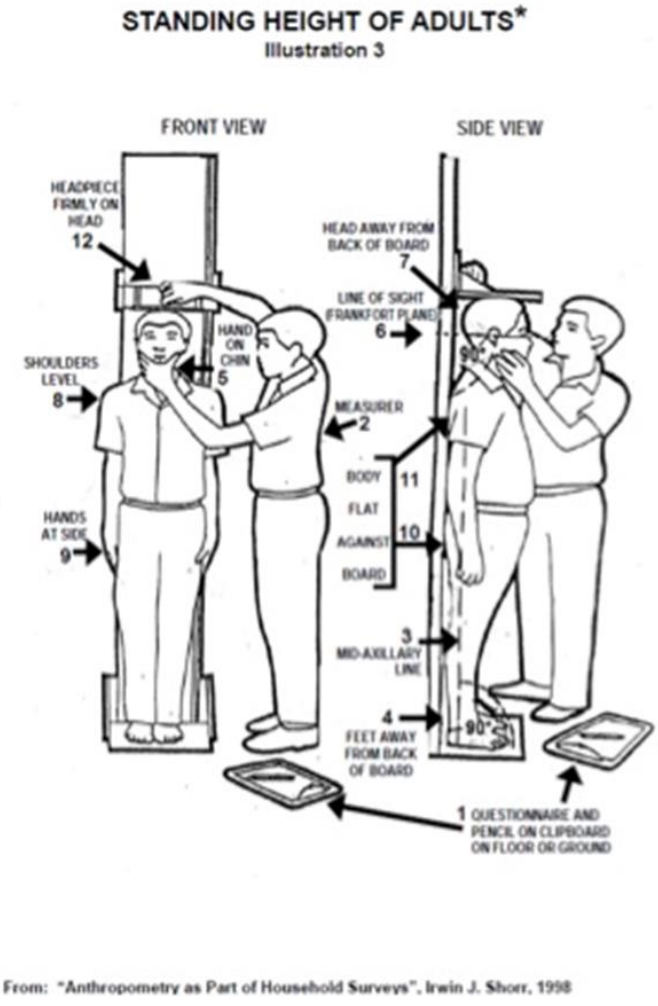

Figure A.1 Height Measurement Diagram Pilot Study

- Weight for Participant
    - Zero the scale
    - Have the Participant remove their shoes and outer clothing and step onto the scale backwards so that they do not see their weight
    - Zero the scale
    - Position the participant and direct them to stand in the center of the scale platform facing the recorder, hands at sides, looking straight ahead.
    - Record the measurement according to the nearest 0.1 kg.

Instruction on App use for the Next Month

If participant has been randomized to Spendee

Ask the participant to open their phone and go to the app store. Ask them to search for 'Spendee' and download 'Spendee Budget & Money Tracker' app. Once it's downloaded, ask the participant for permission to use their phone to set up the app.

Open the app and click 'New to Spendee'. Create a new account using the same google login information created earlier in the day. Ask the participant how they would like their name to appear in the app and enter it accordingly on the next page.

Once the account has successfully been created, go to 'Settings', click on 'Notification settings' and activate 'Remind me to add transactions'. If need be, alter the phone settings to allow notifications from Spendee app – if this is necessary, Spendee will notify you and a pop-up will present itself to allow you to change this setting. Set the reminder time for 10:30 am daily.

Once this is done, give the participants their phone back and proceed with the following script:

Your Spendee account is now set up and ready to use. Spendee is a personal finance tracking app. You are able to create "wallets" which are different budgets. You're also able to connect your bank accounts to the app, if you wish, or log transactions manually. You log various income and expenditures within the wallet. When you log an income or expenditure, select a subcategory and a dollar amount. It's extremely important that you log immediately after spending or receiving money and that you log every day. For the study, you are being asked to log every transaction until we see you for visit 2. We've also set it up so that the app sends you a daily reminder to track your transactions. We ask that you don't alter the notification settings, but feel free to change other settings as you see fit.

We will be sending you weekly surveys every *insert day of week of visit 1* to your U-M email. They will be asking you questions about your use of the app over the prior week. These surveys will only take approximately 3 minutes to complete but are very important so please be sure to complete them.

Additionally, we do have access to your account, but will not be checking your account during the time you are logging. So please be as truthful and as thorough as possible when tracking.

hand the participants the sheet with their username and password Here is your username and password, should you need it. The app keeps you logged in, so you should not need it. Do not change the username or password.

If participant has been randomized to MyFitnessPal

Ask the participant to open their phone and go to the app store. Ask them to search for 'MyFitnessPal' and download the app. Once it's downloaded, ask the participant for permission to use their phone to set up the app.

Open the app and click 'Sign Up', and then 'Sign Up with Email'. For goal click 'Maintain Weight'. For Activity Level click 'Not Very Active'. Under 'You', Click 'Female', 'United States' and a Zip Code of '48109'. Enter the birthday that the participant entered in the visit 1 survey. Enter the height and weight from the anthropometrics collected earlier in the visit. Enter the email and password that was set up previously and set the username as the email without '@gmail.com' and click 'Sign Up'. MyFitnessPal will automatically create a calorie goal, which you will change. Unclick 'Use my phone to track my steps' and 'Send me the latest news, innovations, and offers from MyFitnessPal and Under Armour', keep 'Keep me on track with reminders' checked then press 'Continue'.

At this point, calculate actual calorie needs by using Miffilin St. Jeor calculator (https://www.calculator.net/calorie-calculator.html), the anthropometrics collected earlier in the visit, and their response to the question 'During the past seven days, on how many days were you physically active for a total of at least thirty minutes per day? (Add up all the time you spent in any kind of physical activity that increased your heart rate and made you breathe hard some of the time.)'. Once you have an estimated calorie need for weight maintenance, go into the settings, then select 'Goals' → 'Calorie, Carbs, Protein and Fat Goals' and alter the calories to be the number calculated. The macronutrient distribution goals will adjust accordingly.

Also in settings click 'Reminders'. Deselect reminders for lunch, dinner, and weekly weights. Keep breakfast selected, but change the time to 10:30 am. If necessary, change the settings to allow notifications from MyFitnessPal. The app will notify you at the top of the reminders if the notifications are currently disabled.

Once this is done, give the participants their phone back and proceed with the following script:

Your MyFitnessPal account is now set up and ready to use. MyFitnessPal is an app for tracking what you eat and drink. Immediately after you eat, you go on the app and add the food or drink under the appropriate meal or snack category. To log a food, you click 'add food' and can either search by name, or if it has a barcode, you can scan it in. Be sure to log everything you consume, including drinks and condiments.

It's extremely important that you log immediately after eating or drinking and that you log every day. For the study, you are being asked to log everything you eat or drink until we see you for visit 2. We've also set it up so that the app sends you a daily reminder to track what you eat. We ask that you don't alter the settings within the app. Additionally, do not connect other apps you use to MyFitnessPal, and only use the app to track your food and drink intake.

We will be sending you weekly surveys every *insert day of week of visit 1* to your U-M email. They will be asking you questions about your use of the app over the prior week. These surveys will only take approximately 3 minutes to complete but are very important so please be sure to complete them.

Additionally, we do have access to your account, but will not be checking your account during the time you are logging. So please be as truthful and as thorough as possible when tracking.

hand the participants the sheet with their username and password Here is your username and password, should you need it. The app keeps you logged in, so you should not need it. Do not change the username or password.

Make Appointment for Visit 2

"As a reminder, you need to track daily in the smartphone app starting tomorrow and until you come to your next appointment. Now let's look to see when we can schedule visit 2 for. Are you available at all on *insert the date of 30 days from visit 1 here*?"

(if no), "Okay. How about the following day?" Repeat until you find a day or get to day 35. At which point, "We must schedule this within 30-35 days of visit 1. Is there a time later at night, earlier in the morning, or on a weekend that would work for you?".

(if yes), Schedule at a time that works for both parties. If not, repeat above steps.

Gift Card and HSIP Protocol

Give participant the HSIP gift card. Tell them that it is considered taxable income.

<u>After Visit 1</u>

- Enter height and weight into REDCap
- If visit 1 survey filled out on paper, enter info into REDCap
- Put scheduled visit 2 into calendar, checking that there are no issues

- Set reminders for reminder email/call and weekly emails
- Store study folder in locked cabinet in RA office
- Send appointment confirmation reminder email to participants (text below)

Appointment Confirmation Email

Subject: Appointment Confirmation for Tracking our Lives Study on *insert date of appointment 2* at *insert time of appointment*

Dear *insert participant name here*,

Thank you for participating in the Tracking our Lives Study. This email is to confirm that you have an appointment with us for *insert date and time* at the following location:

North Ingalls Building, 300 North Ingalls Street, Ann Arbor, MI 48109 (Click for a map).

A member of the research team will meet you in the lobby.

If you plan on driving, please plan to arrive 10-15 minutes before your scheduled appointment time to find parking. Both U-M Blue Busses and AATA busses have service stops near North Ingalls Building.

As a reminder, please use the smartphone application everyday between *insert date after visit 1* until your second visit on *insert date of visit 2*. In addition, we will be sending you a survey via email once per week until your next appointment. Please remember to fill these surveys out to the best of your ability.

If you have any questions, or need to reschedule, please reply to this email or call us at (734) 274-9239.

Thank you,

Sam

Between visits 1 and 2

Be sure to send out email every week on the same day that they came in for visit 1.

Three business days prior to Study Visit 2

Send Appointment Reminder Email

Subject: Appointment Reminder for Tracking our Lives Study

Dear *insert participant name here*,

This is just a reminder that you have an appointment for the Tracking our Lives Study on *insert date and time here*. The study visit will be held at the following location:

North Ingalls Building, 300 North Ingalls Street, Ann Arbor, MI 48109 (Click for a map).

A member of the research team will meet you in the lobby.

If you plan on driving, please plan to arrive 10-15 minutes before your scheduled appointment time to find parking. Both U-M Blue Busses and AATA busses have service stops near North Ingalls Building.

If you have any questions, or need to reschedule, please reply to this email or call us at (734) 274-9239.

Thank you,

Sam

Reminder Text Message

Hi *insert name here*, this is a reminder that you have an appointment for the Tracking our Lives Study on *insert date and time here*.

The study visit will be held at North Ingalls Building, 300 North Ingalls Street, Ann Arbor. A member of the research team will meet you in the lobby.

If you have any questions, or need to reschedule, please call or text this number or email hahnsam@umich.edu. Thanks!

Reminder Phone Call

Hi *insert name here*, this is Sam from the Tracking our Lives Study. I was just calling to remind you that you have a study appointment scheduled for *insert date and time here* Does that still work for you?

(if no, reschedule within 3 days of first appointment).

(If yes) Great! The study visit will be at Room 979 of North Ingalls Building at 300 North Ingalls Street in Ann Arbor.

If you plan on driving, please plan to arrive 10-15 minutes before your scheduled appointment time to find parking. Both U-M Blue Busses and AATA busses have service stops near North Ingalls Building.

The appointment will last about an hour and fifteen minutes. If you have difficulty finding the room, please text or call this number. Someone will assist you in finding the lab.

Do you have any questions? *(if yes, answer questions).*

Great, we look forward to seeing you soon!

Day of Study Visit 2

Reminder text/call/email

Send a reminder text/call/email with the following message: Hi *insert name here*, this is Sam from the Tracking our Lives Study reminding you of your appointment today at *insert time* at

North Ingalls Building. If you are running late, get lost, or need to cancel, please call (734) 274-9239. or email hahnsam@umich.edu We look forward to seeing you today!

Assemble Study Folder

Assemble the participant folder with the following documents:

- Visit 2 questionnaire*
- Deception description with list of resources
- Anthropometrics form
- Gift card
- Laptop

*the survey will be administered via REDCap on the laptop, but if there are any issues, research staff will administer by hand.

Be sure that the laptop is charged.

Fill out Study Visit Prep on REDCap

Fill out the Study Visit Prep section on REDCap with information about the HSIP number, and gift card number.

Gather Study Visit Materials

- Folder
- Laptop
- Two pencils
- Do not disturb sign

Table A.2 Pilot Study Visit 2 Timeline

Time	Activity
20 minutes	Participants complete Visit 2 Questionnaire
5 minutes	Participants' height and weight measured
5 minutes	HSIP Payment
2 minutes	Give participants deception/resources worksheet

Study Visit Outline

Put the study materials in the room. Go down to the lobby of 300 N Ingalls Building 10 minutes before the scheduled study time and escort the participant to the room.

Visit 2 Questionnaire

Using the laptop login to REDCap and confirm that you have the correct Study ID for the REDCap forms. Open up the questionnaire in survey mode and give the participant the laptop. If REDCap isn't working, use the paper copy of the Visit 2 Questionnaire.

Allow participants to complete the questionnaire on their own.

Anthropometry Protocol

At visit 2 we will only be collecting weight.

- Weight for Participant
    - Zero the scale
    - Have the Participant remove their shoes and outer clothing and step onto the scale backwards so that they do not see their weight
    - Zero the scale

- Position the participant and direct them to stand in the center of the scale platform facing the recorder, hands at sides, looking straight ahead.
- Record the measurement according to the nearest 0.1 kg.

Be sure to record the weight neatly and clearly on the anthropometric form.

Gift Card and HSIP Protocol

Give participant the HSIP gift card. Tell them that it is considered taxable income.

After visit 2

- **IMMEDIATELY:** log into MFP or Spendee account and change the password so that participants no longer have access to their account
- Enter height and weight into REDCap
- If visit 2 survey filled out on paper, put into REDCap
- Store study folder in locked cabinet in RA office

Appendix D : Mental Health Resources

Tracking our Lives Pilot Study

Thank you for participating in our study. The purpose of this study was to understand how the use of self-monitoring smart phone applications impact college student's eating disorder risk. You were not informed of the full purpose of the study prior to the start of the study because it may have affected the results.

If you experience any mental health issues, we encourage you to take advantage of resources that are available to U-M students within the community and those available online. Below are a list of mental health and eating disorder resources that you may find useful.

Counseling and Psychological Services (CAPS):

(734) 764-8312

3100 Michigan Union, Ann Arbor, MI

University Health Service (UHS):

(734) 764-8320

207 Fletcher St, Ann Arbor, MI

CampusMindsWork for U-M Students

Searchable database to help students manage their mental health illnesses

https://campusmindworks.org/

U-M Comprehensive Eating Disorders Program:

(734) 232-7531, or toll-free 877-475-6688

1540 East Hospital Drive, Level 5, Reception B, Ann Arbor, MI

U-M Psychological Clinic:

(734) 764-3471

530 Church St, Suite 2463, Ann Arbor, MI

The inclusion of your data is voluntary and if you wish to have your data excluded from the study you may do so by notifying Samantha Hahn at hahnsam@umich.edu.

Appendix E : Recruitment Email for Fully Powered Trial

Dear Students,

You are invited to participate in an important research study on the use of a smartphone app that tracks aspects of your daily life and how it impacts well-being.

You may be eligible if you are:

1) At least 18 years old
2) Identify as Female gender
3) Have daily access to a smartphone
4) Will be able to attend two study visits in Ann Arbor that are one month apart.

If you would like to participate, click here to complete a brief eligibility survey (link: https://redcapproduction.umms.med.umich.edu/surveys/?s=937TXK8JRE). The survey should take you approximately 5 minutes to complete. If you are eligible, we will invite you to participate in 2 study visits and may ask you to use an app for one month. You can receive up to $50 for participating.

If you have any questions or concerns, please contact Samantha Hahn at hahnsam@umich.edu.

Thank you for your consideration.

Sincerely,

Samantha Hahn

Appendix F : Consent for Fully Powered Trial

Consent to be Part of a Research Study

Title of the Project: Tracking our Lives Study

Principal Investigator: Samantha Hahn, MPH, RD, Department of Nutritional Sciences, University of Michigan School of Public Health

Faculty Advisor: Kendrin Sonneville, ScD, RD, Department of Nutritional Sciences, University of Michigan School of Public Health

Faculty Advisor: Katherine Bauer, PhD, Department of Nutritional Sciences, University of Michigan School of Public Health

Co-investigator: Niko Kaciroti, PhD, Department of Biostatistics, University of Michigan School of Public Health

Co-investigator: Daniel Eisenberg, PhD, Department of Health Management and Policy, University of Michigan School of Public Health

Invitation to be Part of a Research Study

You are invited to participate in a research study. In order to participate, you must be a University of Michigan undergraduate student, identify as female, speak English fluently, be at least 18 years of age, and have daily access to a smart phone. In order to participate, you must not have any significant cognitive, psychosocial, or medical illness that would limit your ability to provide consent or participate in study procedures, have a medical diagnosis that affects your dietary intake, have a current or past history of an eating disorder, and cannot have tracked your dietary intake in the last year. Taking part in this research project is voluntary.

What is the study about and why are we doing it?

The purpose of the study is to understand how the use of self-monitoring smart phone applications impact college student's well-being. Further details on the nature of the purpose of the study will be given to you at the end of the study. We hope that the results of this study will help improve recommendations for using smart phone applications to improve health.

What will happen if you take part in this study?

If you agree to take part in this study, you will complete a study visit today that will last approximately 35 minutes. You will fill out a survey and then you may be asked to download a specific smartphone application on your phone and instructed how to use that smart phone application. You will be weighed and have your height measured at the end of the visit today but will not be shown your weight or height. After today's visit, you may be asked to use a smartphone app daily for one month. After one month, you will come back for a second study visit where you will again be asked to fill out a survey and will be weighed. This visit will last approximately 25 minutes. You may also be asked to complete a short interview at the end of visit 2 about your experience during the study.

How could you benefit from this study?

We do not expect that you will significantly benefit from being in this study. Others might benefit because we hope that the findings from this study will help improve the recommendations for smartphone app use in the future.

What risks might result from being in this study?

There are some risks you might experience from being in this study. Some questions asked in the surveys may make you feel uncomfortable. You may opt not to answer questions. If you are asked to use the app, using the smartphone app may make you feel uncomfortable. You can choose to stop using the app at any time; just tell the researcher you want to stop. Resources to obtain psychological assistance are available from the researchers if you desire that information.

How will we protect your information?

We plan to publish the results of this study. To protect your privacy, we will not include any information that could directly identify you.

We will protect the confidentiality of your information by storing your name separate from the data collected as part of the project. Research data will be stored on a password protected computer. While unlikely, there is a risk your information, such as your weight, may become known to other people, which could cause you discomfort.

It is possible that other people may need to see the information we collect about you. These people work for the University of Michigan and government offices that are responsible for making sure the research is done safely and properly.

If you are asked to use an app, researchers will not access the contents of your smartphone app while you are using it. After the study is complete, researchers will change the password on the

account and sign you out of the app so that you no longer have access to your account after the study.

What will happen to the information we collect about you after the study is over?

We will keep your information to use for future research. Your name and other information that can directly identify you will be kept secure and stored separately from the information collected as part of the project.

We may share your information with other investigators without asking for your consent again, but it will not contain information that could directly identify you.

How will we compensate you for being part of the study?

To thank you for taking part in our study, you will be paid $25 at the end of visit 1, and $25 at the end of visit 2. Should you decide to withdraw from the study prior to the end of visit 1, you will not be compensated. If you withdraw from the study after visit 1 and before the completion of visit 2, you will receive a total of $25. Should you complete both visit 1 and visit 2, you will receive a total of $50.

Your Participation in this Study is Voluntary

It is totally up to you to decide to be in this research study. Participating in this study is voluntary. Even if you decide to be part of the study now, you may change your mind and stop at any time. You do not have to answer any questions you do not want to answer. If you decide to

withdraw before this study is completed, information collected up to that point may be used in the study.

Contact Information for the Study Team and Questions about the Research

If you have questions about this research, you may contact:

Principal Investigator: Samantha Hahn, MPH, RD **Mailing Address:** SPH 1, 1415 Washington Heights, Ann Arbor, MI 48109 **Email:** hahnsam@umich.edu
Faculty Advisor: Katherine Bauer, PhD **Mailing Address:** 3854 SPH I, 1415 Washington Heights, Ann Arbor, MI 48109 **Telephone:** (734) 763-2546 **Email:** kwbauer@umich.edu

Your Consent

By signing this document, you are agreeing to be in this study. Make sure you understand what the study is about before you sign. We will give you a copy of this document for your records. We will keep a copy with the study records. If you have any questions about the study after you sign this document, you can contact the study team using the information provided above.

I understand what the study is about and my questions so far have been answered. I agree to take part in this study.

_____

Printed Subject Name

_____

Signature Date

Consent to Use Data for Future Research

I agree that my information may be shared with other researchers for future research studies that may be similar to this study or may be completely different. The information shared with other researchers will not include any information that can directly identify me. Researchers will not contact me for additional permission to use this information.

***YES*_____ *NO*_____**

_____

Signature Date

Appendix G : Protocol for Fully Powered Trial

Once Participants Completes Screening Questionnaire

If participant is deemed eligible from pre-screening questions on survey distributed via REDCap, study staff will contact participants to confirm eligibility and to provide information about the study. If participant is deemed eligible and interested, they will be asked to schedule an in-person study visit in the North Ingalls Building at the University of Michigan in Ann Arbor.

If they selected text as their preferred method of contact

Hi *insert name from screening survey*, this is Sam from the Tracking our Lives Study at the University of Michigan. You expressed interest in our study when we sent out an email through the Office of the Registrar, and I wanted to give you more information about our study. In the survey that you filled out, you indicated that you were XXX years old, an undergraduate student at the University of Michigan Ann Arbor, identify as female, have daily access to a smartphone and would be willing to download and use an application on your smartphone for this study, that you do not currently have any medical conditions that impact the types or amount of food that you eat, that you do not currently have or have ever had an eating disorder, that you haven't tracked what you've eaten in the last year. Is this information correct?

(if ineligible) At this time, you are not eligible to participate in the study. Thank you for your time and interest.

(if eligible) Thank you. Participation in the study involves coming to our lab in North Ingalls Building on the University of Michigan Ann Arbor Campus for a study visit that will last about 30 minutes. During this visit, you will complete a questionnaire, have your height and weight measured, and may be instructed on how to use a smartphone application. You will be compensated $25 for your time. You may be asked to use the application for one month. One

month later you will return for study visit 2 where you will again have your weight taken and fill out another survey. You may also be asked to do a brief interview. At the end of study visit 2, you will be compensated an additional $25. Do you have any questions and are you interested in participating? *(Answer any questions).*

(If not interested) Thank you for your time, I really appreciate you speaking with me. Have a great rest of your day.

(If interested) Okay, great. Let's set up a time for you to come in. Our office is located on North Ingalls Street, near the hospital. We're scheduling visits on weekdays up until 7pm. Is there a day or time that works best for you? *(Pull up google calendar and schedule a time for Monday-Friday, 8:00 a.m. – 7:00 p.m. Be sure to check that there are no conflicts with others' schedules for NIB room 979 and that it is during a time study staff are available).*

The email that I have on file is *insert email from screening survey*, is that correct? Can I email you the details for finding us?

(If incorrect, get email and update in REDCap)

(If correct) I will go ahead and send that email now. We also like to remind participants of their appointments a few days in advance. Would you prefer that we email or text to remind you? *(Note preference in REDCap).*

Do you have any questions for me? *(Answer any questions).*

Great, thank you so much for your time and we look forward to seeing you on *insert appointment date and time*. Please don't hesitate to reach out if you have any questions to this phone number or my email, umtolstudy@gmail.com.

Once appointment confirmed, do the following:

7) Create an event on the study calendar with the following format: Participant # - Study Visit 1
8) Create an event on the calendar for the room
9) Send participant appointment confirmation email

If their preferred contact method was email

Subject: Interest in Tracking our Lives Study

Hi *insert name here*,

My name is Sam from the Tracking our Lives Study at the University of Michigan. I was contacting you because you expressed interest in our study when we sent out an email through the Office of the Registrar, and I wanted to give you more information about our study.

In the survey that you filled out, you indicated that you were *insert age here*, an undergraduate student at the University of Michigan Ann Arbor, identify as female, have daily access to a smartphone and would be willing to download and use an application on your smartphone for this study, that you do not currently have any medical conditions that impact the types or amount of food that you eat, that you do not currently have or have ever had an eating disorder, and that you haven't tracked what you've eaten in the last year. Is this information correct?

Participation in the study involves coming to our lab in North Ingalls Building on the University of Michigan Ann Arbor Campus for a study visit that will last about 30 minutes. During this visit, you will complete a questionnaire, have your height and weight measured, and be instructed on how to use a smartphone application. You will be compensated $25 for your time. You may be asked to use the application for one month and return for a second visit one month

later. At the second study visit you will again have your weight measured and fill out another survey. At the end of study visit 2, you will be compensated an additional $25.

If you are still interested in participating in our study please email me back with days and times that work best for you to come in for your first visit. We're scheduling visits on weekdays up until 7pm.

Additionally, if you have any questions please feel free to reach out.

Thank you,

Sam

(if email back that no longer interested note that in REDCap) Thank you for your time, have a great day.

(if email back that the info is correct and that they're interested in participating – update in REDCap and confirm appointment time).

Thank you so much, we look forward to seeing you on *insert appointment date and time*. We also like to remind participants of their appointments a few days in advance. Would you prefer that we call, email, or text to remind you? *(Note preference in REDCap).*

In the meantime, please don't hesitate to reach out if you have any questions to this email or my phone number, (734) 249-9124.

Thank you,

Sam

Once appointment confirmed, do the following:

4) Create an event on the study calendar with the following format: Participant # - Study Visit 1
    a. I would make appointments for 45 minutes, just to be safe.
5) Create an event on the calendar for the room with the following format: Small room TOL Study
6) Send participant appointment confirmation email
7) Update study task list to include 3 day reminder and day of reminder with the following formats:
    a. #XXX – 3 day Reminder
    b. #XXX – Day of Reminder
8) Update participant contact and face sheet

Right after study visit is scheduled

Appointment Confirmation Email

Subject: Appointment Confirmation for Tracking our Lives study on *insert date of appointment* at *insert time of appointment*

Dear *insert name here*,

Thank you for participating in the Tracking our Lives Study. This email is to confirm that you have an appointment with us for *insert date and time* at the following location:

North Ingalls Building, 300 North Ingalls Street, Ann Arbor, MI 48109 (Click for a map).

A member of the research team will meet you in the lobby.

If you plan on driving, please plan to arrive 10-15 minutes before your scheduled appointment time to find parking. Both U-M Blue Busses and AATA busses have service stops near North Ingalls Building.

If you have any questions, or need to reschedule, please reply to this email or call us at (734) 249-9124.

Thank you,

Your name

Three business days prior to Study Visit 1

Send Appointment Reminder Email

Subject: Appointment Reminder for Tracking our Lives Study

Dear *insert name here*,

This is just a reminder that you have an appointment for the Tracking our Lives Study on *insert date and time here*. The study visit will be held at the following location:

North Ingalls Building, 300 North Ingalls Street, Ann Arbor, MI 48109 (Click for a map).

A member of the research team will meet you in the lobby.

If you plan on driving, please plan to arrive 10-15 minutes before your scheduled appointment time to find parking. Both U-M Blue Busses and AATA busses have service stops near North Ingalls Building.

If you have any questions, or need to reschedule, please reply to this email or call us at (734) 249-9124.

Thank you,

Your name

Reminder Text Message

Hi *insert name here*, this is a reminder that you have an appointment for the Tracking our Lives Study on *insert date and time here*.

The study visit will be held at North Ingalls Building, 300 North Ingalls Street, Ann Arbor. A member of the research team will meet you in the lobby.

If you have any questions, or need to reschedule, please call or text this number or email umtolstudy@gmail.com. Thanks!

Day of Study Visit 1

Reminder text/call/email

Send a reminder text/call/email with the following message: Hi *insert name here*, this is Sam from the Tracking our Lives Study reminding you of your appointment today at *insert time* at North Ingalls Building. If you are running late, get lost, or need to cancel, please call (734) 249-9124 or email umtolstudy@gmail.com. We look forward to seeing you today!

Randomization, preparing Smartphone Application Account

Randomly select one of the 200 cards to determine which study arm the participant will belong to. If the card you select is even then the participant has been randomized to control, and if the card is an odd then they have been randomized to the intervention. Do not put the card back in the pile, there will be another pile labeled "used", which is where you will put the card that you selected. Assemble a username and password for MyFitnessPal if they are randomized to the intervention. The email should be the umtolstudy+XXX@gmail.com where XXX is a random number generated. The password is to be generated using a random password generator at https://passwordsgenerator.net/. For the password, do 8 character length with the following settings: exclude symbols, include numbers, include lowercase, include uppercase, exclude similar characters, exclude ambiguous characters, generate on your device, do not auto-select

and do not save my preferences. Create a document for the participant that indicates the application username and password. Record this information in REDCap.

Assemble Study Folder

Assemble the participant folder with the following documents:

- Consent form (x2)
- Visit 1 questionnaire*
- Anthropometrics form
- Gift card
- Laptop

*the survey will be administered via REDCap on the laptop, but if there are any issues, research staff will administer by hand.

Be sure that the laptop is charged.

Fill out Study Visit 1 HSIP Section on REDCap

Fill out the Visit 1 HSIP section on REDCap with information about the HSIP number and gift card number.

Determine Approximately When Visit 2 Should Occur

Determine what date is 30 days after visit 1, and therefore, when visit 2 should occur. Record what days fall within the 30-35 day window in the study folder. The gift card number is the first 7 numbers on the envelope. Also fill out the HSIP tracking form located in the second drawer of the file cabinet.

Gather Study Visit Materials

- Folder
- Laptop

- Two pencils
- Do not disturb signs

Table A.3 Full Study Visit 1 Timeline

Time	**Activity**
5 minutes	Review study consent and obtain participant consent
15 minutes	Participants complete Visit 1 Questionnaire
5 minutes	Participants' height and weight measured
5-10 minutes	Participants download and are instructed on how to use application if randomized to intervention group
2 minutes	Schedule next visit
2 minutes	HSIP Payment

Study Visit Outline

Put the materials for the study visit in the room. Go to the lobby of 300 N Ingalls Building 10 minutes before the scheduled meeting time and escort them to the study room.

Consent

Sit across the table from the participant and give her a copy of the informed consent. Have the participant sign both copies of the informed consent, and sign both copies yourself – one copy is given to the participant and the other copy is kept for study records.

Visit 1 Questionnaire

Using the laptop login to REDCap and confirm that you have the correct Study ID for the REDCap forms. Click on the study ID, click Visit 1 Survey, and then in the upper right hand corner of the survey, click 'Survey Options' and then select 'Open Survey'. Make the survey a

separate window and slide the computer over to participants so that they can complete the survey on their own.

Anthropometry Protocol

Tell participants, “Now I’m going to measure your height and weight.”

- Use figure 1 for reference
- Place the measuring board against a hard, flat surface, making sure the board is stable.
- Have participant remove shoes, bulky, outer clothing, hats, and any buns, braids, hair ornaments, or jewelry from the top of the head (based on willingness of the Participant).
- Place the questionnaire and pencil on the floor or ground and stand on the left side of the person.
- If you cannot do above, find the best scenario, and take notes of any deviations from the protocol and the reason why.
- Position the participant and explain procedures out loud.
- Ask participant to stand on the base of the height measuring board and face forward. Gently guide them onto the board and instruct them to back up until a part of their body touches the board (buttocks or shoulders).
- Help Participant place their knees and feet in the correct position, with knees and feet either together or apart. Instruct them to bring their legs together until their knees or feet touch. There are three possible positions for knees and feet (whichever touches first!)
    - Knees together, feet together
    - Knees together, feet apart
    - Knees apart, feet together

- Determine if the participant's feet should be against or away from the back of the height board by observing the imaginary line drawn from the tip of the shoulder to the heel, which is called the "mid-axillary line" (arrow 3). This line should be perpendicular (i.e. 90 degrees) to the base of the height board where the person is standing. Note that with almost all adults, you will have to move the person's feet away from the back of the height board to put them in the proper position (arrow 4).
- Ask the person to look straight ahead. Place your left hand on the person's chin and gradually close your hand (into a U) (arrow 5). Position the person's head so that the line of sight (i.e. the Frankfort Plane) is parallel to the ground or perpendicular (i.e. 90 degrees) to the back of the measuring board (arrow 6). Note that with most adults, the back of the head will not touch the back of the height board – there will be space between the back of the person's head and the back of the height board (arrow 7).
- After you have placed the person's head in the proper position, release your hand from the person's chin and ask her to hold her head in the position you have just placed it. Check from the front that the head is straight from the front. Adjust if needed.
- Make sure the person's shoulders are level (arrow 8), the hands are at the person's sides (arrow 9) and at least the buttocks touch the back of the board. Note that with most all adults, only the buttocks and perhaps the shoulder blades will touch the back of the measuring board (arrows 10 and 11).
- Check positioning: stand at a 45-degree angle to the measurement board and check to make sure the participant is in the proper position without moving away from the stadiometer.

- Lower the stadiometer head piece: When the Participant's position is correct, lower the headpiece on top of the head (arrow 12) making sure to push through the person's hair. Read and call out the measurement to the nearest 0.1 cm. Raise the headpiece away from the person's head and escort the person off the height board while repeating the measurement in a low audible voice.
- Record the measurement legibly and erase any errors.

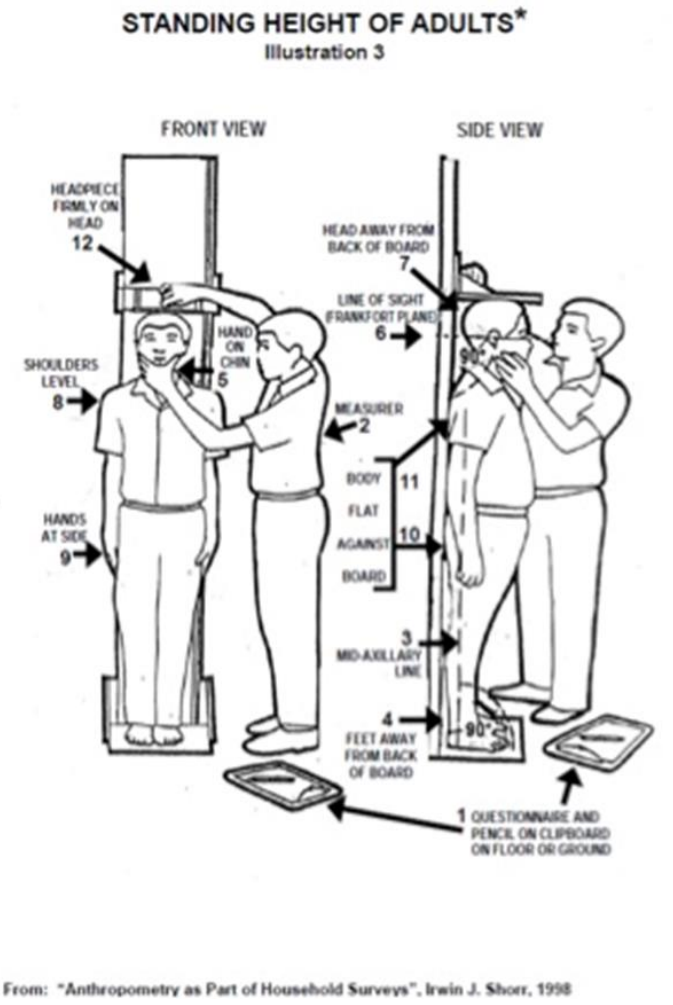

Figure A.2 Height Measurement Diagram Full Study

- Weight for Participant
    - Zero the scale

- Have the Participant remove their shoes and outer clothing and step onto the scale backwards so that they do not see their weight
- Zero the scale
- Position the participant and direct them to stand in the center of the scale platform facing the recorder, hands at sides, looking straight ahead.
- Record the measurement according to the nearest 0.1 kg.

Instruction on App use for the Next Month

If participant has been randomized to MyFitnessPal

Ask the participant to open their phone and go to the app store. Ask them to search for 'MyFitnessPal' and download the app. Once it's downloaded, ask the participant for permission to use their phone to set up the app.

Open the app and click 'Sign Up', and then 'Sign Up with Email'. For goal click 'Maintain Weight'. For Activity Level click 'Not Very Active'. Under 'You', Click 'Female', 'United States' and a Zip Code of '48109'. Enter the birthday that the participant entered in the visit 1 survey. Enter the height and weight from the anthropometrics collected earlier in the visit. Enter the email and password that was set up previously and set the username as the email without '@gmail.com' and click 'Sign Up'. MyFitnessPal will automatically create a calorie goal, which you will change. Unclick 'Use my phone to track my steps' and 'Send me the latest news, innovations, and offers from MyFitnessPal and Under Armour', keep 'Keep me on track with reminders' checked then press 'Continue'.

At this point, calculate actual calorie needs by using Miffilin St. Jeor calculator (https://www.calculator.net/calorie-calculator.html), the anthropometrics collected earlier in the

visit, and their response to the question ‘During the past seven days, on how many days were you physically active for a total of at least thirty minutes per day? (Add up all the time you spent in any kind of physical activity that increased your heart rate and made you breathe hard some of the time.)’. Once you have an estimated calorie need for weight maintenance, go into the settings, then select ‘Goals’ → ‘Calorie, Carbs, Protein and Fat Goals’ and alter the calories to be the number calculated. The macronutrient distribution goals will adjust accordingly.

Also in settings click ‘Reminders’. Deselect reminders for lunch, dinner, and weekly weights. Keep breakfast selected, but change the time to 10:30 am. If necessary, change the settings to allow notifications from MyFitnessPal. The app will notify you at the top of the reminders if the notifications are currently disabled.

Once this is done, give the participants their phone back and proceed with the following script:

Your MyFitnessPal account is now set up and ready to use. MyFitnessPal is an app for tracking what you eat and drink. Immediately after you eat, you go on the app and add the food or drink under the appropriate meal or snack category. To log a food, you click ‘add food’ and can either search by name, or if it has a barcode, you can scan it in. Be sure to log everything you consume, including drinks and condiments.

It’s extremely important that you log immediately after eating or drinking and that you log every day. For the study, you are being asked to log everything you eat or drink until we see you for visit 2. We’ve also set it up so that the app sends you a daily reminder to track what you eat. We ask that you don’t alter the settings within the app, including that notification. Additionally, do not connect other apps you use to MyFitnessPal, and only use the app to track your food and drink intake.

Additionally, we do have access to your account, but will not be checking your account during the time you are logging. So please be as truthful and as thorough as possible when tracking.

hand the participants the sheet with their username and password Here is your username and password, should you need it. The app keeps you logged in, so you should not need it. Do not change the username or password.

Make Appointment for Visit 2

*if the participant is randomized to MyFitnessPal: "As a reminder, you need to track daily in the smartphone app starting tomorrow and until you come to your next appointment."

all "Now let's look to see when we can schedule visit 2 for. What is your availability on *insert the date of 30 days from visit 1 here*?"

(if no), "Okay. How about the following day?" Repeat until you find a day or get to day 35. At which point, "We must schedule this within 30-35 days of visit 1. Is there a time later at night, earlier in the morning, or on a weekend that would work for you?".

(if yes), Schedule at a time that works for both parties. Be sure to check the study calendar as well as the room calendar. If not, repeat above steps expanding beyond 35 days.

Gift Card and HSIP Protocol

Give participant the HSIP gift card. Tell them that it is considered taxable income.

<u>After Visit 1</u>

- Enter height and weight into REDCap
- If visit 1 survey filled out on paper, enter info into REDCap
- Put scheduled visit 2 into calendar, checking that there are no issues
    - Schedule for 45 minutes, though most appointments will be closer to 20 minutes.
- Set reminders for reminder email/call and half way email in tasks list for study calendar

- Store study folder in locked cabinet in RA office
    - Be sure to take each part of the material and put it in the appropriate place
- Send appointment confirmation reminder email to participants (text below)

Appointment Confirmation Email

Subject: Appointment Confirmation for Tracking our Lives Study on *insert date of appointment 2* at *insert time of appointment*

Dear *insert participant name here*,

Thank you for participating in the Tracking our Lives Study. This email is to confirm that you have an appointment with us for *insert date and time* at the following location:

North Ingalls Building, 300 North Ingalls Street, Ann Arbor, MI 48109 (Click for a map).

A member of the research team will meet you in the lobby.

If you plan on driving, please plan to arrive 10-15 minutes before your scheduled appointment time to find parking. Both U-M Blue Busses and AATA busses have service stops near North Ingalls Building.

If randomized to MyFitnessPal

As a reminder, please use the smartphone application everyday between *insert date after visit 1* until your second visit on *insert date of visit 2*.

If you have any questions, or need to reschedule, please reply to this email or call us at (734) 249-9124.

Thank you,

Sam

Between visits 1 and 2

Send Appointment Reminder Email

Subject: Appointment Reminder for Tracking our Lives Study

Dear *insert participant name here*,

This is just a reminder that you have an appointment for the Tracking our Lives Study on *insert date and time here*. The study visit will be held at the following location:

North Ingalls Building, 300 North Ingalls Street, Ann Arbor, MI 48109 (Click for a map).

A member of the research team will meet you in the lobby.

If you plan on driving, please plan to arrive 10-15 minutes before your scheduled appointment time to find parking. Both U-M Blue Busses and AATA busses have service stops near North Ingalls Building.

If randomized to MyFitnessPal

As a reminder, please use the smartphone application everyday between now and your second visit on *insert date of visit 2*.

If you have any questions, or need to reschedule, please reply to this email or call us at (734) 249-9124.

Thank you,

Sam

Three business days prior to Study Visit 2

Send Appointment Reminder Email

Subject: Appointment Reminder for Tracking our Lives Study

Dear *insert participant name here*,

This is just a reminder that you have an appointment for the Tracking our Lives Study on *insert date and time here*. The study visit will be held at the following location:

North Ingalls Building, 300 North Ingalls Street, Ann Arbor, MI 48109 (Click for a map).

A member of the research team will meet you in the lobby.

If you plan on driving, please plan to arrive 10-15 minutes before your scheduled appointment time to find parking. Both U-M Blue Busses and AATA busses have service stops near North Ingalls Building.

If you have any questions, or need to reschedule, please reply to this email or call us (734) 249-9124.

Thank you,

Sam

Reminder Text Message

Hi *insert name here*, this is a reminder that you have an appointment for the Tracking our Lives Study on *insert date and time here*.

The study visit will be held at North Ingalls Building, 300 North Ingalls Street, Ann Arbor. A member of the research team will meet you in the lobby.

If you have any questions, or need to reschedule, please call or text this number or email umtolstudy@gmail.com. Thanks!

Day of Study Visit 2

Reminder text/email

Send a reminder text/call/email with the following message: Hi *insert name here*, this is Sam from the Tracking our Lives Study reminding you of your appointment today at *insert time* at North Ingalls Building. If you are running late, get lost, or need to cancel, please call (734) 249-9124. or email umtolstudy@gmail.com We look forward to seeing you today!

Assemble Study Folder

Assemble the participant folder with the following documents:

- Visit 2 questionnaire*
- Deception description with list of resources
- Anthropometrics form
- Gift card
- Laptop

*the survey will be administered via REDCap on the laptop, but if there are any issues, research staff will administer by hand.

Be sure that the laptop is charged.

Fill out Study Visit Prep on REDCap

Fill out the HSIP and Username/Password sections on REDCap with information about the HSIP control number, gift card number, and new password (The password is to be generated using a random password generator at https://passwordsgenerator.net/. For the password, do 8 character length with the following settings: exclude symbols, include numbers, include lowercase, include uppercase, exclude similar characters, exclude ambiguous characters, generate on your device, do not auto-select and do not save my preferences.)

Gather Study Visit Materials

- Folder
- Laptop
- Two pencils
- Do not disturb sign

Table A.4 Full Study Visit 2 Timeline

Time	**Activity**
15 minutes	Participants complete Visit 2 Questionnaire
2 minutes	Participants' weight measured
2 minutes	Give participants deception/resources worksheet
2 minutes	HSIP

Study Visit Outline

Put the study materials in the room. Go down to the lobby of 300 N Ingalls Building 10 minutes before the scheduled study time and escort the participant to the room.

Visit 2 Questionnaire

Using the laptop login to REDCap and confirm that you have the correct Study ID for the REDCap forms. Click on the study ID, click Visit 2 Survey, and then in the upper right hand corner of the survey, click 'Survey Options' and then select 'Open Survey'. Make the survey a separate window and slide the computer over to participants so that they can complete the survey on their own.

If REDCap isn't working, use the paper copy of the Visit 2 Questionnaire.

for those in the intervention group

Once they are done with the survey, ask them to get their phone out and to go to MyFitnessPal. You will change the password to the password that you generated before the visit. To do this in the app go to 'Settings' →'Sharing & Privacy' →'Change Password'. Once you've changed the password successfully, go back to the setting menu and click 'Log out' and hand the participant their phone back. If there are any issues with this, trouble shoot with the participants.

Anthropometry Protocol

At visit 2 we will only be collecting weight.

- Weight for Participant
    - Have them remove their shoes and any bulky or heavy clothing
    - Zero the scale
    - Position the participant and direct them to stand in the center of the scale platform facing **BACKWARDS**, hands at sides, looking straight ahead.
    - Record the measurement according to the nearest 0.1 lb. ***note, be sure that when you're writing it and dealing with other paperwork that you're not letting them see.

Be sure to record the weight neatly and clearly on the anthropometric form.

At this point, if they ask for their height or weight, we can inform them.

Deception

Give the participants that deception form and say, "The purpose of the study was to understand how the use of self-monitoring smart phone applications impact college student's eating disorder risk. You were not informed of the full purpose of the study prior to the start of the study because it may have affected the results. Here is more information and a list of mental health resources."

Gift Card and HSIP Protocol

Give participant the HSIP gift card. Tell them that it is considered taxable income.

After

Thank the participants again form participating in the study and walk them to the elevator.

<u>After visit 2</u>

- Enter weight into REDCap under ‘Visit 2 weight’ and mark as complete.
- Update Username/Password if necessary in REDCap
- If visit 2 survey filled out on paper, put into REDCap
- Update Contact Sheet to Complete
- Update participant facesheet on REDCap –
    - Current participant status changed to ‘participant complete’
    - Status checklist ‘ completed study visit 2’ and ‘participant complete’ selected
    - Double check the date and time of study visit 2
    - Select ‘No’ for ‘was the second study visit cancelled?’
- Store filled out ‘End of Study Information’ sheet in hanging folder – putting the last participant in the back
- Ensure that all participant information is in REDCap and mark each section as Complete

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