

UPTAKE OF A WEARABLE ACTIVITY TRACKER IN A COMMUNITY-BASED WEIGHT
LOSS PROGRAM

Anna Elizabeth Taggart

Thesis submitted to the faculty of the Virginia Polytechnic Institute and State University in
partial fulfillment of the requirements for the degree of

Master of Science
In
Human Nutrition, Foods, and Exercise

Paul A. Estabrooks, Chair
Samantha M. Harden,
Kathryn E. Wilson,
Wen You

Blacksburg, VA

April 21 2016

Keywords: Obesity, wearable devices, weight loss, incentives, RE-AIM, reach, social cognitive
theory, behavioral science

UPTAKE OF A WEARABLE ACTIVITY TRACKER IN A COMMUNITY-BASED WEIGHT LOSS PROGRAM

Anna Elizabeth Taggart

ABSTRACT

The purpose of this thesis was to determine the proportion of participants enrolled in a community-based weight loss program that would accept and use a wearable device (Fitbit) if included as part of the program. A sample of 526 newly enrolled, adult, female weight loss program participants ($BMI \geq 30 \text{ kg/m}^2$) were recruited. Participants were randomized to either a Fitbit experimental condition or no-Fitbit control condition, and received emailed information on program features. The experimental condition email also included a free Fitbit offer. The full sample ($n=526$) was 44 ± 12.6 years old with a BMI of $37 \pm 6.2 \text{ kg/m}^2$. The proportion of experimental sample ($n=266$) that accepted and synced was 50% and 23%, respectively. Twenty-two participants in the control condition (8%) also independently obtained and synced a Fitbit. Ninety-nine percent passively declined (did not respond to request for Fitbit color and size information). Those that declined were older (46 ± 13.4 vs. 42 ± 11.3 years of age, $p=.001$) and weighed less (214 ± 38.9 lbs. vs. 231 ± 41.3 lbs., $p=.01$) than those who accepted. Those in the experimental sample who synced were younger (42 ± 10.0 vs. 45 ± 13.2 years of age, $p=.012$), and weighed more (237 ± 45.2 lbs. vs. 217 ± 38.1 lbs., $p=.002$) than those who accepted but did not sync. This thesis provides preliminary support that 23% of participants will accept and sync a free wearable device. These data can be used for decision making, combined with effectiveness and cost data, and research on wearable activity trackers and community, incentive, and web-based weight loss.

UPTAKE OF A WEARABLE ACTIVITY TRACKER IN A COMMUNITY-BASED WEIGHT LOSS PROGRAM

Anna Elizabeth Taggart

GENERAL AUDIENCE ABSTRACT

This thesis was embedded within a larger pragmatic randomized controlled trial developed to determine if the provision of a wearable device would improve community program participant engagement and weight loss success over a 12-month period, at a reasonable incremental cost. The purpose of this thesis was to determine the proportion of participants that would accept and use a wearable device (Fitbit) if it were included as part of the community program. A sample of 526 newly enrolled (<30 days), adult, female weight loss program participants with a BMI ≥ 30 kg/m² were recruited. Participants who synced a Fitbit when joining were excluded. Participants were randomized to the 1) Fitbit experimental condition or 2) no-Fitbit control condition. Both groups received emailed information on features of the community program, but the experimental group included a free Fitbit offer and information on how to sync it to the program. The full sample (n=526) was 44±12.6 years old with a BMI of 37±6.2 kg/m². The proportion of experimental group participants (n=266) that accepted and synced the Fitbit was 50% and 23%, respectively. Of those that declined the Fitbit, 99% did so passively, by not responding to a request for size and color Fitbit information. Those that declined were older (46±13.4 vs. 42±11.3 years of age, $p<.001$) and weighed less (214±38.9lbs. vs. 231±41.3lbs., $p<.01$) than those who accepted. Those in the experimental sample who synced a Fitbit were younger (42±10.0 vs. 45±13.2 years of age, $p<.012$), and weighed more (237±45.2lbs. vs. 217±38.1lbs., $p<.002$) than those who accepted but did not sync a Fitbit. Twenty-two participants in the control condition (8%) also independently obtained and synced a Fitbit. This thesis provides preliminary support that approximately 23% of participants in a web-based, weight loss program will accept and sync a free wearable device. Overall, those who accepted and synced the Fitbit were younger and weighed more than those who did not. These data can be used for budget allocation decision making when combined with effectiveness and cost data at the completion of the larger trial, as well as research on wearable activity trackers and community, incentive, and web-based weight loss.

ACKNOWLEDGMENTS

First, I would like to acknowledge my advisor, Paul Estabrooks for believing in me and bringing me on as a graduate student in Human, Nutrition, Foods, and Exercise (HNFE). I would not be where I am in now if it wasn't for connecting with him through Carilion Wellness. I am forever grateful for all of his support, financially, physically, and emotionally, over the past two years of school, and for all of the opportunities to learn, grow and expand my knowledge in the areas of implementation science and health related research. I cannot thank you enough!

I also want to acknowledge our research practice partners, IncentaHealth, for collaborating with and supporting us on this thesis project. In particular, thank you to Todd McGuire, Lia Schoepke, Jack Rule, Carol Tanner, Suman Juvvalapalem, and all of the Weigh and Win Health Coaches for helping and contributing to this study. Specifically, I want to thank IncentaHealth for their financial support as well. I hope the outcomes are beneficial and useful for growing and enhancing the Weigh and Win program, and I look forward to seeing how the program develops in the future.

I also want to acknowledge my co-advisor, Samantha Harden for taking me on as her first graduate student and mentoring me along the way. I want to thank her for her financial support and contribution to this thesis project. I am lucky to have her as a mentor and a part of my committee. I have really enjoyed working with her and I have learned about so much more than just research. I appreciate all of the time, energy, and dedication spent helping make me a better researcher, writer, and professional. I also appreciate her dealing with my frequent questions and supporting me during difficult times.

I would also like to acknowledge and thank one of my other committee members, Kathryn Wilson, who has been with us on this project since day one. I don't know what we would do without her. She is a special person and one of the most intelligent people I know. I can't thank her enough for all of her help, support, mentoring, energy, and for all of her countless hours working with me on participant recruitment, data collection and analysis, and edits.

I would also like to acknowledge and thank Wen You for being on my committee and assisting with my thesis. It has been so great having an outside perspective from the HNFE research team for this thesis. I appreciate all of your help and support.

I also want to give a big thank you to my VT Rec Sports family, specifically Ali Cross, Steven Trotter, Liz Greenlee, and Krista Gwilliam, for giving me the opportunity to obtain my graduate degree. I would not be here if it was not for all of their continued support, encouragement, understanding, and love.

I also want to acknowledge and thank my lab group and other HNFE graduate students and colleagues for helping me with the transition into graduate school and understanding the many challenges along the way. It is a great feeling to be a part of such an astounding, passionate, dedicated, and supportive team and department.

I also want to acknowledge and thank my personal family, including my parents, brothers, and grandparents, my friends, my roommate Kemia, and my church family. I want to thank them for encouraging me to continue pursuing this degree and supporting me during all of the tough times. I want to thank them all for the countless prayers, food, hugs, and words of encouragement.

Finally, I want to acknowledge and thank Matt Minahan for being my biggest supporter and cheerleader throughout this crazy process. I am so thankful for having him help me deal with my stress and for being so understanding and accommodating to my busy schedule.

TABLE OF CONTENTS

Chapter 1: Introduction -----	Page 6
Introduction-----	Page 6
Wearable Devices-----	Page 7
Wearable Devices and Behavior Change-----	Page 9
Chapter 2: Literature Review -----	Page 13
Community Based Weight Loss Programs-----	Page 13
Web-Based Approaches to Weight Loss-----	Page 15
Incentive-Based Approaches to Weight Loss-----	Page 16
Determining Community-Based Weight Loss Program Impact – The Need to Address Reach-----	Page 18
Chapter 3: Methods -----	Page 22
Study Rationale-----	Page 22
Integrated Research-Practice Partnership-----	Page 23
Study Design-----	Page 23
Population, Eligibility, and Recruitment-----	Page 24
Blinding Participants of Intervention Assignment-----	Page 25
Procedures-----	Page 25
Measures and Data Collection-----	Page 26
Reach-----	Page 27
Demographic Data-----	Page 27
Email and Fitbit Latency-----	Page 28
Data Analysis Plan-----	Page 28
Chapter 4: Results -----	Page 29
Sample Baseline Data-----	Page 29
Figure 1-----	Page 30
Table 1-----	Page 31
Reach Indicators-----	Page 32
Race and Ethnicity-----	Page 33
Cost-----	Page 34
Email and Fitbit Latency-----	Page 34
Chapter 5: Discussion -----	Page 35
Limitations-----	Page 40
Future Directions-----	Page 40
Conclusions-----	Page 41
References -----	Page 42

Chapter 1:

Introduction

Introduction

Although there is a large body of research supporting physical activity and proper nutrition to reduce the risk of chronic disease, many people are not meeting public health recommendations (Ward et al. 2013). The incidence of chronic disease is exacerbated by the fact that only 49% of adults meet the guidelines for aerobic physical activity, and only 21% meet the guidelines for aerobic and muscle strengthening physical activity (Ward et al. 2013 & United States Department of Human Services, 2010). Additionally only 43% consume recommended fruit per day and 57% consume recommended vegetables per day (Ward et al. 2013 & United States Department of Human Services, 2010). Furthermore, seventy percent of adults are overweight or obese and 6% are extremely obese (Fryar et al., 2015).

Obesity is a complex disease associated with many comorbidities, which stem from the interaction of multiple personal and environmental factors, and is associated with health care costs totaling \$190 billion annually (Trogden, 2008). Increases in obesity-related diseases are projected to add over \$50 billion a year to health care costs in the United States by the year 2030 (Wang et al., 2011). It is for these reasons that obesity prevention and treatment is a high priority health concern, and sustainable population- and community-based health interventions are needed. Fortunately, there is strong evidence that weight loss programs that promote caloric reduction of approximately 500 kcals/day, increased physical activity to approximately 60 minutes/day, and the use of behavioral strategies can support weight loss (Donnelly et al., 2009). In addition, one of the strongest predictors of weight loss maintenance is sustained physical activity (Donnelly et al., 2009).

Wearable Devices

Accelerometry-based activity monitors are the most popular and regularly used devices to measure physical activity for research purposes (Lee, 2014). In recent years there has been an emergence of accelerometer-based devices aimed at the consumers (Ferguson, 2015). Consumer targeted wearable devices could assist with measurement issues associated with self-reported physical activity assessment (Lewis et al., 2015) and represent a useful self-monitoring tool for weight loss interventions. Self-monitoring, or the ability to regulate behavior to accommodate situations (Michie et al., 2009), is one of the most salient behavior change strategies (Michie et al., 2013), and could be enhanced through the use of a wearable activity tracker (Michie et al., 2013 & Fritz et al., 2014).

Over the past few years, there has been an increase in popularity and demand for consumer based activity trackers, which provide value to the consumers as well as the researchers (Lee, 2014). Activity trackers are evolving each year as the technology continues to advance. They provide consumers with the ability to estimate daily physical activity over extended periods of time, and often include technology to monitor steps and heart rate, estimate energy expenditure, utilize global positioning systems (GPS), and track sleep patterns (Lee, 2014). The wearable technology market will get close to \$6 billion dollars by 2016, making the use of fitness trackers the number one fitness trend in 2016 (Thompson, 2015). Still, the Consumers and Wearable's report, delivered twice a year as part of the Connected Intelligence WEAR practice, reported that only ~10% of U.S. adults own a wearable fitness device, but that there are gender, age, and income differences between fitness tracker and smartwatch owners when compared to those that do not own a wearable device (NPD Group/Connected Intelligence Consumers and Wearables Report, 2016). Women are more likely to own a fitness tracker (54%

of owners), but men are more likely to own a smartwatch (71% of owners; NPD Group/Connected Intelligence Consumers and Wearables Report, 2016).

Consumer based activity trackers have adapted over the years, beginning with the 2006 Nike+ system, which included a pod that was attached to a user's shoe and controlled wirelessly through a smartphone to monitor the duration and/or distance of a workout (Meyer & Boll, 2014). GPS Polar watches were released to monitor heart rate and track activity using GPS, and not long after, the Fitbit was introduced in 2009, followed by the Jawbone UP and Nike's Fuel Band, which all track steps and some track distance walked/run and calories burned (Meyer & Boll, 2014). Wearable activity trackers that measure physical activity, sleep, and other behavioral patterns have emerged as potential tools to assist with population health management, health promotion, and disease prevention (Patel et al. 2015). Most of these devices are worn around the wrist to accommodate the consumer and increase wear time of the device (Meyer & Boll, 2014).

With the growth of technology and "smart fitness", these devices increasingly have the ability to sync wirelessly, transfer data, and share information via social media and other electronic platforms (Lee, 2014). Though issues such as reliability and validity are essential for research purposes, it is important to remember that the consumer is more focused on the device being reliable and providing information on increasing or decreasing activity during a given period of time (Meyers & Boll, 2014). Rooksby et al. conducted interviews with activity tracker users and found that participants did not decide to lose weight as a result of purchasing or downloading an activity tracker, but instead purchased or downloaded an activity tracker because they wanted to lose weight or accomplish a certain short-term goal (Rooksby et al. 2014). They also discovered that tracking is more of a social and collaborative activity rather than personal and independent, illustrating how activity trackers can be more about personal motivation, goal

setting, and self-monitoring rather than the quantification of one's progress in physical activity behaviors as described by numbers alone (Rooksby et al. 2014)..

While consumer based wearable devices may both improve objective measures of physical activity and health behaviors (Lee, 2014), less is known about the degree to which using a wearable device may improve long-term health behaviors as they relate to weight loss. Further, there are no published reports on the uptake of wearable devices if provided in conjunction with a weight loss program, or the ability of wearable devices to promote sustained behavior change when added to a scalable weight loss program. Despite the widespread emergence of consumer based wearable devices, there is a dearth of information on whether these devices can promote sustained behavior change for physical activity, nutrition, and weight loss, and the feasibility of including activity trackers in commercial weight-loss programs.

Wearable Devices and Behavior Change

Some activity trackers have been integrated into programs as a means to promote healthier lifestyles (Lewis et al., 2015). The appeal of these devices lies in their ability to assist individuals in non-invasively monitoring behavior while avoiding biases involved with self-reporting. For employers and insurers, the devices represent objective measures of behavior change that accurately track physical activity (Case et al., 2015). A recent review indicates that studies that include activity trackers rarely also include evidence-based principles of health behavior change (Lee & Finkelstein, 2013). That is, acquisition of a device promotes device use rather than health-related behavior strategies (e.g., self-monitoring, goal setting, and feedback). Most studies in the area of wearable activity trackers and behavior change discuss personal informatics and the idea of self-monitoring as a persuasive technology strategy, which can

influence one's behavior and action (Fritz et al., 2014 & Michie et al., 2013). Activity trackers offer a popular and convenient way to assess the effects of self-monitoring.

In a recent study by Fritz et al., participants (n=30) were recruited for semi-structured in depth interviews on wearable device use including, motivation, accounting, goals and rewards, and sharing data (Fritz et al., 2014). Participants reported achieving weight loss and fitness goals, as well as changes they had made in their everyday lives that affect their activity levels while using the device (Fritz et al., 2014). Participants also reported being motivated by knowing and being aware of their data, despite the fact that their goals may change over time (Fritz et al., 2014). Although this study did not report on objective measures of behavior change, it demonstrates the importance of self-monitoring with a wearable activity tracker in health behavior modification, as well as how activity trackers can motivate people and help them achieve their goals. It also gives support for the need of more studies with activity trackers as an objective measure of behavior change.

Some studies with activity trackers have explored the incorporation of Short Message Service (SMS – i.e. text message) prompts to increase physical activity. Wang et al. found that participants (n=67) in a six-week randomized controlled trial who used a Fitbit achieved a small increase in MVPA at six-week follow-up and SMS prompts were inadequate at increasing PA past the first week (Wang et al. 2015). Although text messaging has the potential of reaching a large audience, future studies on health behavior modification should look at other ways to engage participants, such as longer interventions and individualized coaching.

In 2015, Lewis et al. conducted a systematic review of electronic activity monitors including the Fitbit, in physical activity interventions in which only 5 of the 11 studies reported on weight loss (Lewis et al., 2015). Of these 5 studies, two reported on changes in BMI and

another two found significant differences in body weight between the group with electronic activity monitors and control group, which were partially explained by the additional dietary modification component of the intervention. A conclusion made from this review was that electronic activity monitors might be more effective when added as a component of a larger behavioral intervention versus on their own. Though this summary of literature indicated that there may be promise in using activity monitors to increase physical activity and decrease weight, more randomized controlled trials are needed to determine the overall effect of electronic activity monitors, which features are most effective, and which populations can benefit most. A community-based weight loss program with established behavior change strategies could be a potential place to assess these effects.

Use of wearable devices is increasing, but overall reach into the population is low, suggesting that incorporating a wearable device into community-based weight loss programs might improve the attractiveness of the program by including a tool to support evidence-based, behavioral weight management strategies such as self-monitoring and feedback (Michie et al., 2009). Further, given the positive relationship between physical activity and weight loss maintenance (Franz et al., 2007), including a wearable device in a community weight loss program could enhance and sustain changes in weight over a long period of time. Unfortunately, to date, the reach of strategies such as integrating wearable devices within community weight loss programs has not been documented. There are no reports related to the proportion and characteristics of participants that would accept a wearable device if it was offered as part of a program. Furthermore, it is unclear if the costs of integrating such a device would support widespread integration of the provision of activity trackers within scalable weight-loss programs. This thesis was developed as part of a larger trial to inform the implementation of community

weight loss programs with regard to the uptake, costs, and effectiveness associated with integrating a wearable fitness tracker. The specific focus of this thesis was to determine the proportion of participants that accepted and synced a wearable device with the context of the community weight loss program while also examining the characteristics of those who accept and sync the device with those that do not.

Chapter 2:

Literature Review

Community-Based Weight Loss Programs

Interventions aimed at improving weight status often involve altering diet and physical activity because weight is influenced by energy intake and expenditure (calories in and out) (Panel, 1998). Sustained weight loss of 3%-5% produces clinically meaningful health benefits, with greater weight loss producing even greater benefits (Jensen et al. 2014). Further, weight loss can decrease the risk of premature mortality associated with other obesity related diseases, and should begin with lifestyle modifications that can be sustained by changes in behavior (Panel, 1998). Population-and community-based weight loss interventions help people adopt changes in behavior that are needed and learn how they can modify and monitor their lifestyle.

One goal of Healthy People 2020, which has influenced the development of community-based weight loss interventions, focuses on social determinants of health and states that health starts at home and in our social networks, where the promotion of good health and good health resources can help improve health outcomes (United States Department of Human Services, 2014). Healthy People, which provides 10-year national goals based on scientific evidence from many diverse groups of people and organizations to improve the health of all Americans (healthypeople.gov), states that environments including school, workplace, healthcare, and the community are all settings in which research is needed to explore how certain programs can affect and improve the health of individuals, to inform public policy and create positive change. It is for these reasons that community-based resources and health programs are needed (Kahn et al. 2009).

A systematic review of 80 studies (N = 26,455) was conducted and determined that interventions that combine diet and exercise have the most significant weight loss effects when compared to those that target each behavior separately (Franz et al., 2007). They further report that self-monitoring, goal setting, stimulus control, reinforcement, cognitive change, and social support are all core behavioral weight loss strategies used in most weight loss interventions (Franz et al., 2007). The outcomes of this review are consistent with American Dietetic Association's guidelines for weight management, which recommend both diet and physical activity, as well as behavioral therapy for at least 6 months, with a maintenance program implemented after that time (Krauss et al., 2000). Goals for weight loss should be to reduce body weight by 0.5-1 kg per week for 6 months to achieve a 10% weight loss goal from baseline (Franz et al., 2007), which provided a platform for the development of community interventions targeting weight loss across a variety of populations.

An analysis of 122 dietary and physical activity interventions for different behavioral change strategies concluded that the greatest change effects were achieved with self-monitoring (Michie et al., 2009). Successful community-based weight loss programs often focus on the concept of self-regulation, a form of self-monitoring, and goal setting for reducing energy intake and increasing energy expenditure (Michie et al., 2009). In order for people to change their behaviors, it is important for them to first pay attention to their actions and how those actions influence important outcomes (Conroy et al., 2011). In a randomized controlled trial by Conroy et al. (2011), self-monitoring of physical activity and weight loss in overweight adults was evaluated for 6 months. Higher levels of physical activity and greater weight loss were associated with more frequent self-monitoring of physical activity and diet, and greater adherence to physical activity goals (Conroy et al., 2011). However, the study did see a decrease

in overall physical activity self-monitoring and adherence to goals over time (Conroy et al., 2011). This suggests that those who have goals and are given feedback regarding health behaviors are more successful in changing their behaviors. However, research also needs to be conducted to assess maintenance of this behavior change and weight loss over time, as well as discovery of new technology to improve adherence to self-monitoring behavior.

In a systematic review of 22 studies (N = 9,668) (6 randomized controlled trials) on self-monitoring of diet, exercise, and self-weighing components of weight loss interventions, a significant association between self-monitoring and weight loss was reported (Burke et al., 2011). Self-monitoring adherence was most frequently reported as number of paper diary completions or frequency of reported weights (Burke et al., 2011). One weakness of the included studies was the assessment of self-monitoring through self-report (Burke et al., 2011). Similar to the study by Conroy et al., there was a gradual decline in self-monitoring adherence towards the end of the intervention (Burke et al., 2011). More research is needed to (1) decrease the burden of self-report monitoring of diet and exercise, (2) determine if the use of technology as an objective measure could potentially save time and increase adherence to weight loss, and (3) identify the frequency and duration of self-monitoring that is needed to support this behavior change.

Web-based Approaches to Weight Loss

A growing area of interest is web-based lifestyle interventions delivered in community settings which aim to increase reach and reduce costs associated with face-to-face and in-person group-based strategies, which are often expensive and less preferred by adults due to the time and resources involved (Carpenter et al., 2014). Evidence supports the ability of web-based weight loss programs, providing a personalized, structured program with an emphasis on diet,

physical activity and cognitive-behavioral strategies to support user's weight loss (Carpenter et al., 2014 & Saperstein et al. 2007). Research suggests that communication in a web-based intervention must be “participatory, deeply meaningful, empathetic, empowering, interactive, personally relevant, contextually situated, credible, and convenient” (Neuhauser & Kreps, 2003 pg.18). Furthermore, those who log into a web-based program more frequently lose more weight, suggesting greater participation or engagement in the program leads to better weight loss outcomes (Carpenter et al., 2014 & Saperstein et al., 2007), though little is known about what features contribute to and improve this effect (Neve et al., 2010).

Web- or mobile-based interventions have the potential to reach a larger proportion of the population, and therefore be more impactful. There is a dearth of information on the uptake and reach of web-based tools for the public in relation to generalizability and weight loss (Saperstein et al. 2007). Results of a review on weight loss programs delivered through the internet reported that the majority of the population represented in the studies was educated, Caucasian, female participants (Weinstein et al. 2006), therefore demonstrating limited generalizability. Borrowing from the smoking cessation literature, social support within online smoking cessation treatments has been shown to be an essential component of reach and engagement among online smoking cessation health forums (Stearns et al. 2014). Research is needed to address the areas of uptake, maintenance, and sustainability of web-based programs for long-term behavior change.

Incentive-Based Weight Loss Programs

Behavioral economics is the study of the effects of psychological, social, cognitive, and emotional behaviors on individual's economical decisions, and could be used in an intervention as a potential way to address health behavior change and weight loss (Lowenstein et al., 2007). Incentives have a history in weight loss literature, beginning over 30 years ago with the work of

Jeffery and colleagues (Jeffery et al., 1978). The goal of using incentives within community programs is to enhance participation and improve weight loss outcomes. Because weight loss is takes time, using an incentive could provide an immediate tangible outcome, and potentially help motivate someone to lose weight. Incentivized self-monitoring of behavior combined with a web-based behavioral weight loss intervention could potentially improve engagement, improve program reach, and contribute to greater outcomes.

A randomized controlled trial concluded that those who received a lottery incentive (i.e. randomly selected to earn money for hitting weight loss goals each month) or had a deposit contract incentive (i.e. putting money down and earning it back monthly based on weight loss) with participant matching lost significantly more weight after 16 weeks compared to the control group, who only received an incentive if they met their monthly weight loss goals (Volpp et al., 2008). However, participant weight loss in this study was not sustained, which is often a consistent and constant challenge in weight loss interventions (Volpp et al, 2008 & John et al. 2011). A second challenge for this study was that the sample size was predominantly obese male veterans (Volpp et al, 2008 & John et al. 2011), therefore not generalizable or representative of the overall population. Another randomized controlled trial testing the effectiveness of different financial incentive designs (i.e., individual vs. group incentive) for promoting weight loss among obese employees, reported that those in the group design lost more weight than those in the individual design at 24 weeks, and displayed an increase in cognitive restraint, or self-regulation of their food (Kullgren et al. 2013). However, participants were predominately Caucasian females from one employer, which demonstrates limited representativeness and generalizability (Kullgren et al. 2013). More research is needed to address incentives and long-term maintenance of weight loss, as well as generalizability of study outcomes.

Determining Community Weight Loss Program Impact: The Need to Address Reach

Ultimately, the impact of any community-based weight loss program can only be determined when two variables are combined—effectiveness and reach. A number of authors have pointed toward the need to address multiple program outcomes that include, but move beyond simple assessments of intervention effectiveness (Glasgow et al., 1999 & Abrams et al., 1996 & Pronk, 2003). Reach is described as the number, proportion, and representativeness of participants that engage in an intervention when compared to the target population (Glasgow, 1999). Representativeness refers to the degree to which participant characteristics, usually demographics, are similar to the characteristics of the target population. Literature reviews and studies that report on the testing of wearable devices, community programs, and internet and incentive programs all focus on the degree to which weight loss or behavior change was achieved (i.e., effectiveness) with little to no reference to the potential reach of the interventions.

To achieve a public health impact, weight loss programs need to reach a large proportion of the target population while monitoring the participant representativeness relative to their community in terms of demographic information. A recent review of literature that focused on trials with an explicit goal to balance the reporting of internal and external validity found that just over half of the 101 articles reviewed included a participation rate and just under half reported on representativeness (Harden et al., 2015). Participation rates ranged from two to 100 percent with an average of ~45% (Harden et al., 2015). When considering representativeness, studies appeared to be over represented in the areas of race (more likely to be white), income (more likely to be higher income), and education (more likely to have achieved higher educational status; Harden et al. 2015). A review of the literature on weight loss maintenance reported that only 11% of the studies reported the proportion of the target population that

participated in the study, and only 5% reported on representativeness (Akers et al., 2010). The low attention to proportional reach and representativeness has been replicated across a number of areas of behavioral intervention research (Akers et al., 2011 & Glasgow et al., 2004 & Dziewaltowski et al., 2004).

Related more closely to the goals of this thesis, a systematic review on community-based weight loss interventions (n=80 studies) reported that documentation of participant information was limited to the number enrolled, number of completers, mean baseline weight, mean baseline BMI, mean baseline age, and sex, and no study reported on race, ethnicity, or representativeness (Franz et al. 2007). What does seem to be clear is that, similar to the broader field of behavioral interventions (Harden et al., 2015), the majority of participants in weight loss trials are white women (Burke et al. 2011 & Conroy et al., 2011). As noted in our descriptions above, these findings also seem to generalize to web and incentive-based weight loss programs.

Weigh and Win (WAW), an incentive- and web-based weight-loss program based in Denver, CO, provides an ideal opportunity to test the added benefit of wearable devices embedded within a program that includes feedback loops and incentives. Currently, participants that enroll in Weigh and Win can sync a wearable device, a Fitbit, to track physical activity progress. The Fitbit is one of the most popular wireless activity trackers (Ferguson, 2015). The Fitbit is a lightweight monitor that comes in different sizes and colors, and is most often worn around the wrist. The Fitbit contains a microelectromechanical system triaxial accelerometer and uses an algorithm to estimate energy expenditure based on height, weight, age, and sex. It also has a battery life of about seven to ten hours and can track seven days of detailed minute-by-minute motion data (fitbit.com). However, the Fitbit Classic, an older model activity tracker (worn on the hip) significantly underestimates energy expenditure, based on kcal readings, by

14% for activities such as cycling, laundry, raking, treadmill walking, stairs, and carrying groceries (Sasaki et al., 2014). This tendency of error is also demonstrated in several other validation studies (Dannecker et al and Lee & Welk) of the Fitbit Classic (Sasaki et al., 2014). However, one study confirmed strong validity of seven activity trackers for sleep and steps, and moderate validity for total daily energy expenditure and moderate to vigorous physical activity (MVPA) in free living conditions (Ferguson, 2015). The Fitbit was the most accurate measure of sleep, steps, and energy expenditure out of the seven trackers studied (Ferguson, 2015). According to a recent systematic review of the reliability of consumer wearable activity trackers, certain older Fitbit models demonstrated higher interdevice reliability on steps, energy expenditure, distance, and sleep (Evenson et al., 2015). This information will be useful, as new devices are released each year, and we can see their significance in relation to public health (Ferguson, 2015).

To assess the effects of a Fitbit on participants in the community-, incentive- and web-based weight loss program, Weigh and Win, the research team conducted a non-invasive Quasi-Experimental study. Weigh and Win preliminary program data suggest that program participants who used a Fitbit were more engaged and successful than those who did not. Using existing Weigh and Win data the researchers identified 1,255 participants that enrolled in the program and synced a Fitbit device. For comparison, four groups of 1,255 participants who had not synced a Fitbit were also identified, and the proportion of participants that achieved either a 3 or 5 percent reduction in initial body weight was examined. From these data the researchers found that participants who proactively purchase and use a Fitbit device are nearly two times as likely to achieve a clinically meaningful weight loss, as well as reduction in BMI, when engaged in Weigh and Win. In addition to these findings, participants who used a Fitbit were also more

engaged in the program based on the frequency of program weigh-ins, logins, Facebook posts, and quizzes completed, as well as, greater email opening rates and more text prompts.

What is less clear is the underlying reason for the differences in outcomes between these participants and the four groups of randomly sampled participants. It is unclear if the higher success was due to the wearable device or due to other moderators (e.g. motivation). To confirm these findings we provided a random sample of Weigh and Win participants with Fitbits. The overarching goal of the larger study is to determine if the addition of a wearable device would improve program outcomes for newly enrolled participants in Weigh and Win. Could giving someone a Fitbit to self-monitor his or her physical activity potentially improve engagement and improve reach as well? The RE-AIM framework (Glasgow et al., 2006) was used to guide the study data collection and aims. Specifically, for this thesis study we focused on the potential reach and representativeness of adding a Fitbit at the individual level and implementation cost at the organizational level.

AIMS

The aims of this study are to determine:

1. What proportion of participants would accept a wearable activity tracker when offered as part of a community weight loss program (Reach Indicator 1)
2. What proportion of participants of those that accept a wearable activity tracker would sync it as part of a community weight loss program (Reach Indicator 2)
3. If there were demographic differences between those that accept a wearable activity tracker and those that decline, and between those who synced the tracker and those who did not (Reach Indicator 3).

Chapter 3:

METHODS

Study Rationale

Representatives from Kaiser Permanente, an integrated managed care system, identified a gap in affordable and accessible weight management programming. In partnership with Kaiser Permanente, IncentaHealth, a digital wellness company established Weigh and Win (WAW) in 2011 (weighandwin.com). Weigh and Win is a community-and incentive-based weight loss program located in Denver, Colorado. People from the Denver metro area can sign up for the program from a kiosk located strategically in the community (e.g., library, store, clinic) or from the program website. Community residents that enroll in Weigh and Win and have a baseline BMI that is greater than or equal to 25 kg/m² were eligible to receive quarterly cash rewards based on their percent weight loss. Once enrolled in the program participants can also opt to receive text messages and emails that included information on daily physical activity, nutrition, motivation, tips, and success stories. Participants also have access to online journals, quizzes, team challenges, and videos to help them succeed in the program. Weigh and Win certified personal trainers and health coaches are available to answer participant questions and a points system was in place (HEALTH points) based on program involvement.

Weigh and Win is based on Social Cognitive Theory, which highlights the interactions between the person, the behavior, and the environment (Bandura, 2001). In particular, social cognitive theory constructs of self-efficacy, outcome expectations, and goal setting are targeted through behavioral self-regulation strategies. To enhance self-efficacy Weigh and Win includes messages that address barriers to physical activity and healthful eating as well messages focused on vicarious learning about the success of previous program participants. Outcome expectations

are targeted through the use of modest financial incentives and messages related to the benefits of regular physical activity, healthful eating, and weight control. Goal setting and self-regulation strategies are tied to quarterly weigh-in opportunities and online journaling.

Integrated Research-Practice Partnership

Early in the development of weight loss programming for communities and employers, IncentaHealth engaged in an integrated research practice partnership with scientists in the areas of physical activity, nutrition, weight control, health economics, behavioral change, and implementation science. The shared goal of the partnership was to develop generalizable knowledge related to the impact of scalable weight-management interventions that could be used for internal pragmatic decision-making at IncentaHealth and for scientific advancement in the translation of evidence-based principles into community or clinical practice. The pragmatic RCT described in this thesis was collaboratively developed using the integrated research-practice partnership approach to determine if the provision of a wearable device would enhance program retention and weight loss success, at a reasonable implementation cost. The data collected during this study were expected to contribute to the scientific questions in these areas while also allowing IncentaHealth to consider information related to a potential program adaptation. Initial pragmatic questions to be addressed through this master's thesis included: (1) how many participants would take advantage of a free Fitbit, if offered with the program? (2) how many participants would sync a Fitbit once it was sent to the participant? (3) are there differences in the participant characteristics of those that accept a Fitbit when compared to those that decline?

Study Design

A pragmatic RCT (Tunis et al., 2003) was conducted to determine the reach, initial effectiveness in producing clinically meaningful weight loss and weight loss maintenance after

12 months, incremental costs of including the Fitbit relative to the proportion of participants that achieve a 3 and 5% weight loss (Glasgow et al., 1999). The focus of this thesis was on the initial reach and use of the Fitbit, and representativeness of participants that accepted and synced the device to the WAW program.

Population, Eligibility, and Recruitment

Because of the high proportion of female participants overall in WAW (~80% female) our program partners, IncentaHealth, were most interested in the outcomes of adding a Fitbit in a sample of women. This would have the highest potential impact for WAW and other community weight loss programs, where adult women are the overwhelming majority of participants. The partnership also discussed the need to provide the devices to those that could benefit most and an additional inclusion criteria of a BMI of greater than or equal to 30 kg/m² was included. As a result, all adult (18 years & over) female WAW participants that completed enrollment (online registration and initial weigh-in completed) and had a BMI of greater than or equal to 30 kg/m² were eligible for study participation. Initially a geographic exclusion criteria (further than 5 miles from a WAW kiosk) was used, but was later omitted as the inclusion criteria was found to be too restrictive for participant recruitment. Finally, individuals that already owned a Fitbit were excluded from study participation. The total eligible sample of participants was randomly assigned to the control or experimental group, which was further delineated into those that accepted versus those that accepted the Fitbit and those that declined it. Decliners were also categorized as participants that actively declined the Fitbit offer and participants that passively declined the Fitbit by not responding to the Fitbit offer email. Those who accepted the Fitbit were also grouped into those who synced the Fitbit and those who did not. The Virginia Tech Institutional Review Board (IRB) approved all study procedures.

Blinding Participants to Intervention Assignment

It is possible that fully informing WAW participants that, as part of a study, some participants would receive a free Fitbit and others would not could demotivate participants in the control condition and reduce the potential benefits that could arise from WAW participation. To address this risk, participants were blinded to study participation and a protocol for debriefing all participants at the completion of the larger 12-month study was developed. The Virginia Tech IRB determined the study to be of minimal risk and approved the integration of study conditions within the existing program structure and the blinding of participants to their participation in the randomized controlled trial.

Procedures

The overall trial procedures include tracking costs, participant engagement, and weight loss. This thesis focuses on the procedures developed to track participant uptake and syncing of the Fitbit. First, participants assigned to the experimental condition received an email containing information and instructions on choosing a Fitbit size, color and information on why they were selected to receive the device. Language was also included to indicate that the Fitbit was for participants that did not already own the wearable device. The email also highlighted the WAW program features. After accepting the offer for a free Fitbit by completing a request with size and color requests, participants were sent information on how to set up and sync their Fitbit device to their WAW account. Since some participants did not respond to the email or decided they would not like a Fitbit, we selected additional participants and randomly assigned them to Fitbit or control until 100 participants accepted. Once the participants in the experimental condition requested a size and color Fitbit, the researchers confirmed their request, purchased the Fitbit for them, and then gave the participants an estimated time of arrival. Costs of the Fitbit device was

tracked to encourage device use and provide cost benefit information for future program delivery.

Participants assigned to the control condition received an email describing Weigh and Win program features. The only difference between the emails sent to control vs. experimental groups was the content offering a Fitbit. The emails were the only contact between the researchers and both groups.

Initial time lag between participant enrollment in Weigh and Win and provision of the Fitbit was longer than anticipated. To address the threat to internal validity in the study, the research team increased the sample size to 300 so that participants could be stratified into those who received the Fitbit within 2 weeks of enrolling and those who received the Fitbit longer than two weeks after enrolling. The research team increased the sample size for each group to $n=150$, aiming for 75 participants in the “Late to start” group and 75 participants in the new “Newly enrolled” group for participants assigned to the experimental group, thereby preserving the goal of understanding the effects the Fitbit would have on newly enrolled participants. With this change in recruitment, total recruitment for the study lasted 4 months, and was conducted from June to October, 2015.

Measures and Data Collection

Data collection for the primary outcome of the larger trial was embedded within the WAW program and gathered as part of the program at WAW kiosks on a quarterly basis. Incremental costs were recorded throughout and included Fitbit device and shipping costs. Data related to Fitbit acceptance and sample demographics were gathered during the recruitment period and for one month after the final participants were enrolled in the study. Fitbit syncing data was gathered in March, 2016.

Reach

Reach was assessed as the number, proportion, and representativeness of the participant samples based on the following indicators:

Reach Indicator 1: *The proportion of participants who accept a wearable activity tracker when offered as part of a community weight loss program* was measured using the total number of invited participants and the number of those who accepted, actively declined, and passively declined. This total number randomized was used as the denominator to calculate the proportion of total participants that accepted, actively decline, and passively declined the Fitbit. Active decline was operationalized as eligible participants who contacted the research team to decline a Fitbit, whereas passive decline were operationalized as those who did not send their size and color preference (i.e., confirmation of acceptance).

Reach Indicator 2: *The proportion of participants who synced it when offered as part of a community weight loss program* was measured using the total number of invited participants who synced their Fitbit to the Weigh and Win program.

Reach Indicator 3: *Demographic differences between those that accept a wearable activity tracker and those that decline, and between those who sync it and those who do not* was measured based on socio-demographic indicators including: Age, Initial weight, BMI, Race and Ethnicity.

Demographic Data

Descriptive statistics will be used to determine the average and proportion of age, initial weight, race, ethnicity and initial BMI of enrolled participants. Independent samples t-tests were used to detect differences between groups on age, initial weight, and BMI, and on race and ethnicity using chi-squared tests. A t-test was conducted to compare age, initial weight, and BMI

between 1) the control and experimental samples, 2) the Fitbit accepters and decline samples, 3) the experimental Fitbit synced and the experimental Fitbit not synced samples, 4) the Fitbit accept and sync and the Fitbit accept and not sync samples, and lastly 5) the Fitbit accept and sync sample compared to the control sample who synced a Fitbit.

Participants had six different options for selecting race including, African American, Asian, Caucasian, Native American, Other, and Refuse to answer, and three different options for ethnicity including Hispanic, Non-Hispanic, and Refuse to answer. Due to the power size/expected count of Asians and Native Americans, these variables were collapsed into the “Other” variable.

Email & Fitbit Latency

Initial lag time between participant enrollment and recruitment for the study and between participant recruitment and when the Fitbit were sent was also calculated and measured in days.

Data Analysis Plan

All reach indicators (1-3) were described using proportions. All statistical tests were completed using Statistical Analysis System (SAS) and JMP version 11 (Cary, NC), SPSS version 20 (IBM Corp., 2011). Chi-square and independent t-tests were used to assess the relationship between both the experimental and the control sample, those who accepted the Fitbit and those who did not, and those who synced the Fitbit and those who did not. Significance was set at an alpha of $p < 0.05$.

Chapter 4:

RESULTS

Sample Baseline Data

Participant recruitment and assignment are displayed in Figure 1. The recruitment time period of June 14th 2015 through October 11th 2015 was used for the study, and 2,405 individuals completed online registration for WAW over this period and were assessed for eligibility, with 1,070 enrolled by completing an initial weigh-in (see Figure 1). Of those individuals, 619 were eligible and 546 were contacted and randomly assigned to intervention condition using a random numbers table.

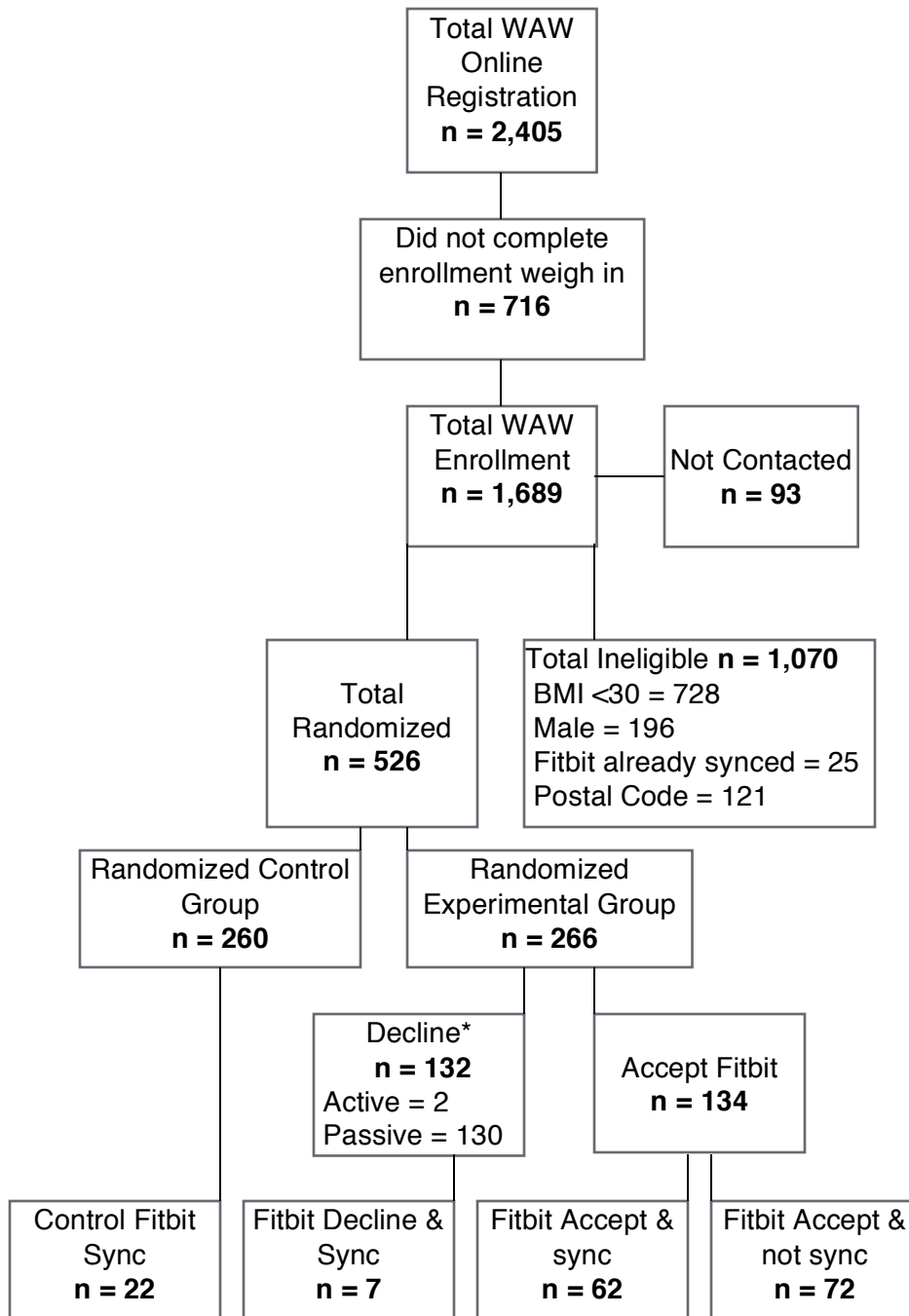


Figure 1. Flow diagram showing participant recruitment and assignment

*Decline: Active – participants who responded back to us via email that did not want the Fitbit
 Passive – participants who did not respond back to us via email

Table 1. *Participant characteristics.*

	Total Sample	Control Sample	All Experimental	Declined Fitbit	Accepted Fitbit	<i>Synced Fitbit</i>	<i>Did Not Sync Fitbit</i>
Total	N= 526	n= 260	n= 266	n= 132	n= 134	n= 62	n= 72
Race, N (%)							
African American	51 (10)	18 (7)	33 (12)	17 (13)	16 (12)	4 (6) ^e	12 (17) ^e
Asian	2 (.4)	1 (.4)	1 (.4)	0 (0)	1 (.7)	0 (0)	1 (1)
Caucasian	356 (68)	179 (69)	177 (67)	81 (61)	96 (72)	50 (81)	46 (64)
Native American	11 (2)	5 (2)	6 (2)	3 (2)	3 (2)	2 (3)	1 (1)
Other	74 (14)	37 (14)	37 (14)	23 (17)	14 (10)	4 (6) ^e	10 (14) ^e
Refuse to answer	32 (6)	20 (8)	12 (5)	8 (6)	4 (3)	2 (3)	2 (3)
Ethnicity, N (%)							
Hispanic	131 (25)	75 (29)	56 (21)	31 (23)	25 (19)	9 (14)	16 (22)
Non-Hispanic	364 (69)	168 (65)	196 (74)	91 (69)	105 (78)	50 (81)	55 (76)
Refuse to answer	31 (6)	17 (6)	14 (5)	10 (8)	4 (3)	3 (5)	1 (2)
Age, M (\pm SD)	44 (\pm 12.6)	43 (\pm 12.6)	44 (\pm 12.5)	46 (\pm 13.4) ^a	42 (\pm 11.3) ^a	42 (\pm 10.0) ^c	45 (\pm 13.2) ^c
Initial Weight, M (\pm SD)	223 (\pm 40.8)	223 (\pm 40.5)	222 (\pm 40.9)	214 (\pm 38.9) ^b	231 (\pm 41.3) ^b	237 (\pm 45.2) ^d	217 (\pm 38.1) ^d
Initial BMI, M (\pm SD)	37 (\pm 6.2)	37 (\pm 6.2)	37 (\pm 6.2)	37 (\pm 6.0)	38 (\pm 6.4)	38 (\pm 6.6)	38 (\pm 6.1)
Email Latency, Days	42 (\pm 107.8)	41 (\pm 104.4)	36 (\pm 46.8)	36 (\pm 37.6)	36 (\pm 54.7)	35 (\pm 25.9)	36 (\pm 70.6)

Note: Corresponding letters a-e reflect significant differences between conditions ($p < .05$)

Reach Indicators:

Reach Indicators 1 & 2

The total number who accepted the Fitbit was 134 of the 266 that were offered the Fitbit (50%). Two participants actively declined the Fitbit (0.4%). The number of participants who passively declined was 130 (49%). When comparing to only those who were offered a Fitbit as part of the experimental sample (n=266), the proportion of those who synced (n=62) was 23%. Twenty-Two participants from the control sample (8%) and seven participants from the decline sample (3%) also purchased and synced a Fitbit with the Weigh and Win program synced.

Reach Indicator 3

Results of the independent samples t-tests demonstrated several significant differences ($p < 0.05$) between the groups on age and initial weight (Table 1). Independent samples t-test demonstrated significant differences in the age for those who accepted a Fitbit (M=42 years of age, SD±11.3) and those who did not respond (M=46 years of age, SD±13.4); $t(255)=2.59$, $p=0.010$. An effect was demonstrated between the age of those in the experimental sample (n=266) who synced a Fitbit (M=42 years of age, SD±10.1) compared to those who did not sync a Fitbit (M=45 years of age, SD±13.2); $t(145)=-2.49$, $p=0.014$. This test also included those from the experimental sample who were part of the decline sample and synced a Fitbit on their own (n=7).

There were also significant differences in the initial weight of those who accepted a Fitbit (M=231lbs., SD±41.8) compared to those who did not respond (M=214lbs., SD±38.9); $t(259)=-3.35$, $p < 0.001$). The results suggest that there was an effect demonstrated between the initial weight of those who accept a Fitbit. A significant effect was also demonstrated on the initial weight in pounds of those in the experimental sample (n=266) who synced a Fitbit (M=237lbs.,

SD_±46.2) compared to those who did not sync a Fitbit (M=217lbs., SD_±38.1); ($t(96)=3.10$, $p=0.003$).

Of note, 22 participants in the control condition independently obtained and synced a Fitbit (M=36 years of age, SD_±10.5). When compared to the rest of the control sample (M=44 years of age, SD_±12.6), they were significantly younger than those who did not sync a Fitbit; ($t(27)=-3.338$, $p=0.002$). In addition, when compared to the experimental sample of participants that accepted and synced a Fitbit, the participants in the control sample that synced a Fitbit were also significantly younger (36 vs. 42 years of age, $p=0.041$) and weighed less (213lbs. vs. 237lbs., $p=0.020$).

Race & Ethnicity

The majority of the sample was Non-Hispanic (69%) Caucasian (68%; Table 1). Participants randomly assigned to the experimental condition were not significantly different in race than those randomly assigned to the control condition, demonstrating accurate randomization of the samples ($\chi^2=6.367$, $p=0.095$; Table 1). However, differences in ethnicity approached significance ($\chi^2=5.132$, $p=0.077$), with a slightly greater amount of Hispanic participants in the control sample. Those that accepted the Fitbit compared to those that declined did not show significant differences in race ($\chi^2=4.075$, $p=0.254$) or ethnicity ($\chi^2=4.199$, $p=0.122$). Those in the experimental sample that synced a Fitbit compared to those that did not showed significant differences in race ($\chi^2=10.899$, $p=0.012$), particularly those who synced the Fitbit were less likely to be African American and Other than those who did not sync. There were no significant differences in ethnicity between those in the experimental sample who synced a Fitbit compared to those who did not ($\chi^2=2.759$, $p=0.252$). Participants who accepted and synced a Fitbit were significantly different in race than those who did not sync a Fitbit

($\chi^2=5.193, p=0.023$; Table 1). However, due to the low expected count, the researcher had to collapse the variables for African Americans, Asians, and Native Americans, and therefore all participants in these variables were included in the Other variable, which was significantly lower in those who synced a Fitbit. There were no significant differences in ethnicity in participants who accepted and synced a Fitbit compared to those who did not ($\chi^2=1.100, p=0.294$). Due to the small number of those in the control sample who synced a Fitbit, a chi-squared test examining difference between those who synced in the control vs experimental groups was underpowered, and therefore not conducted.

Cost

A total of 163 Fitbits were ordered totaling \$19,592.90. Seventeen of these orders were returned due to a mailing address error, which brings the total to 146 Fitbits, and the total cost to \$17,384.70.

Email & Fitbit Latency

The full sample on average received the study email 42 days after enrolling in the Weigh and Win program (Table 1). Participants in the experimental samples (full experimental, Fitbit accepters, and those who declined) had an average of 36 days in between when they enrolled in the Weigh and Win program and when they received the study email asking if they wanted a free Fitbit. Those in the control sample had an average of 41 days in between enrollment and study email. Participants in the Fitbit accept sample that received a Fitbit, received it after an average of 54 days (± 61.5) after they enrolled in the Weigh and Win program. When comparing the email latency of total study participants who synced a Fitbit ($M=33, SD\pm 24.2$) to those who did not ($M=39, SD\pm 87.6$) there were no significant differences demonstrated; $t(484)=-1.191, p=0.234$.

Chapter 5:

DISCUSSION

The purpose of this study was to determine what proportion of participants would accept and sync a wearable activity tracker when offered in conjunction as part of a community-, incentive-, and web-based weight loss program as well as the representativeness of participants who accepted and synced the wearable device. Results from the study indicate that out of those offered a free Fitbit as part of the Weigh and Win program, about 50% accepted it. Of those who accepted the Fitbit, 46% synced it with the Weigh and Win program. This suggests that about 23% of all participants will accept and sync a Fitbit when offered to them for free as part of a weight loss program. Results of the study also indicated that participants who accepted and synced a Fitbit were younger and weighed less than those who did not. Participants who accepted and synced a Fitbit were also more likely to be Caucasian.

Of note, half of the participants who accepted and were sent a free Fitbit did not sync it with the Weigh and Win program. This was contrary to the hypothesis, because 134 free Fitbit devices were supplied to participants already somewhat motivated to lose weight as indicated by enrolling in a weight loss program. However, this may align with the findings of Rooksby and colleagues (2014) that wearable device users were more interested in the social aspects of the technology and less interested in the tool as a weight loss support. Still, our study found that those that accepted and synced the fitbits were heavier at the time of enrollment, indicating that, for some of the WAW population, the Fitbit may be considered a tool that will support weight loss.

Twenty-two participants from the control sample also purchased and synced a Fitbit with the Weigh and Win program. These participants were also significantly younger than other

participants in the control sample and other participants who accepted and synced a free Fitbit when offered. This could be due to the fact that the Weigh and Win program advertises and provides information for all participants on the ability to sync a Fitbit with the program. It could also be because these participants wanted to accomplish a short term goal, similar to the most commonly cited reason participants said when interviewed in the study by Rooksby et al. (Rooksby et al., 2014).

While the Fitbit was free to the participants in the experimental condition, the decision to integrate a Fitbit as part of the community-, incentives-, and web-based program relates to the ability to reach and engage a larger proportion of program participants. It is clear from the literature that more engagement leads to greater weight loss outcomes (Carpenter et al., 2014 & Saperstein et al., 2007). The Fitbit device may be one mechanism by which to reach and engage a larger proportion of Weigh and Win participants—though our study did not examine if advertising a free Fitbit with membership would increase WAW reach. Therefore, to inform the decision-making-process, this study, combined with the natural Fitbit study described above, provide preliminary support for the provision of a free wearable device as participants were three times more likely to sync a Fitbit with the Weigh and Win program. The results of this thesis study—when combined with the effectiveness data—will inform recommendation for or against implementation of a wearable device into the Weigh and Win program with the goal of increasing program effectiveness.

In a review of eleven studies assessing the efficacy and feasibility of a wearable activity tracker, seven studies included over 60% female participants, four studies with predominately Caucasian participants, most with unreported race and ethnicity, and the majority with low sample size ranging between 24-100 participants (Lewis et al., 2015). However, participation

rates, recruitment, and characteristics of the participants compared to the target population, were not commonly discussed (Lewis et al., 2015), similar to the behavioral intervention research described earlier (Akers et al., 2011 & Glasglow et al., 2004, & Dzewaltowski et al., 2004). The results of this pragmatic randomized controlled trial add to the literature on reach of wearable activity trackers in community-, incentive-, and web-based weight loss programs by filling the gap on proportion and representativeness of participants who accept and sync a wearable activity tracker in conjunction with a weight loss program. More research is needed to determine how to improve the reach and representativeness of weight loss programs utilizing a wearable activity tracker and to determine the cost-benefit of doing so.

Participants who enrolled in the Weigh and Win program and accepted and synced a Fitbit were significantly younger. These results, however small, suggest that age had an effect on who accepts a Fitbit when offered as part of a weight loss program. Another randomized controlled trial conducted using an internet-based weight loss program as well also reached a greater amount of younger female participants (Glasglow et al., 2007). A potential explanation for this could be that younger participants are more attracted to and knowledgeable with emerging technologies devices (Comstock, 2016). However, according to a recent survey of 2,600 WebMD users on March, 2016, Millennials (those born between 1980-2000) and Silents (those born prior to 1942) are the least likely generations to use technology like wearable fitness trackers (Comstock, 2016). For Millennials, cost was the most common reason for not using the devices, and the doctor not recommending the device was the most common reason the Silents do not use the device (Comstock, 2016). Based on this information, it is unsurprising that our middle-aged, obese, female participants were likely to accept and sync the free wearable device. To expand the reach of Millennials and Silents, it may be necessary to incorporate a free or low-

cost alternative to Millennials, or a recommendation by a healthcare provider, employer, or insurance company to reach those in the Silents generation.

Fitbits and other wearable activity trackers, as we know from the review above (c.f. Lewis et al.), have grown in popularity in the last ten years. Younger participants have greater exposure, and are more familiar with their popularity and value, as demonstrated in the emergence of the “Quantified Self” movement, the engagement in self-tracking of biological, environmental, behavioral, or physical information, that has grown in recent years, and largely contributed to the increase in wearable device use (Swan, 2013). It is suggested that more individuals will participate in quantified self activities if they are easier, cheaper, and automated (Swan, 2013). This implies that future interventions and research that provide a wearable device, capable of self-tracking and syncing with an online program, and at no cost, are needed to promote and increase self-monitoring and health behavior change.

With the growth of worksite wellness and weight loss interventions (Anderson et al. 2009), the addition of a wearable activity tracker to help promote and monitor physical activity for employees could potentially decrease medical costs related to obesity, and provide employees with a low cost wearable device to do so. Decreasing cost is also commonly mentioned as a reason for choosing a web-based intervention (Tate, 2009). However, a small amount of web-based interventions actually provide this information, making it difficult for decision makers to determine whether or not an intervention is a good investment and use of resources (Tate, 2009). A review of the cost effectiveness of web-based interventions identified eight out of 420 interventions that included cost-effectiveness or cost-benefit information. Of these studies, it was stated that weight loss interventions that cost less than \$50,000 per quality-adjusted life years are a good value (Tate, 2009). The average cost of weight loss interventions reported per participant

ranges from about \$200-\$1,400 (Gustafson et al, 2009). Results of this study suggest that with the provision of a wearable activity tracker, employers and health promotion companies would be able to reach almost 50% of a sample at a cost of \$275 per participant. It will be important to measure and include the cost per pound lost for each of the participants who synced a Fitbit in the Weigh and Win program in follow-up analyses.

The results of this study also suggest that the initial weight of individuals has an effect on those who sync a Fitbit. Specifically, those who weigh more at the time of enrollment were more likely to sync a Fitbit. In an earlier study examining the National Weight Control Registry, participants who self-weighed more frequently had a lower maximum BMI and a lower BMI (Butryn et al., 2007), suggesting that those who weigh less, according to their BMI, are more likely to engage in self-monitoring of weight. However, in the study reported here, BMI was not significant, but this could be because it was controlled and limited to those who were clinically obese with a BMI over 30, similar to many other weight loss studies (Burke et al., 2011). However, the addition of a free Fitbit could have encouraged heavier participants at the time of enrollment to participate and engage in greater self-monitoring behavior, potentially because they had greater social support or had tried and failed another weight loss intervention (Burke et al., 2011).

Lastly, when looking at the representativeness of the samples, the majority of participants in all samples were Caucasian, and the majority of those that accepted and synced a Fitbit were also Caucasian, and less likely to include African Americans in the sample. Results of this study align with the representativeness of other weight loss literature, as described in the review section above (Burke et al. 2011 & Conroy et al., 2011). Future research should include more strategies to target minority populations, such as tailored information for recruitment of these

participants, who also have the highest prevalence of obesity (Bennett et al, 2014 & Harvey & Ogden, 2014).

Limitations

The research team used email for recruitment of participants, and it is unclear if all participants received (e.g. Spam mail), opened, or read the email. Although email is a good way to reach a large amount of people, it has limitation for recruitment. More research is needed to access and strategize more effective ways to reach participants.

A second limitation of the study is that the outcomes are specific to Weigh and Win, which provides a monetary incentive to participants for weight loss. As presented in the literature, not all weight loss interventions provide, or are able to provide an incentive. The first evaluation of the uptake of a wearable activity tracker was also done on female participants in the program from the Denver metro area, as to inform decision making for future program use. Although the outcomes of this study do not include male participants, they reflect representativeness of typical community-, incentive-, and web-based weight loss program participants (i.e., primarily female as seen in the literature review of this thesis).

Future Directions

The results of this study will be used to inform other studies on reach and effectiveness of a wearable device in a weight loss program. Although this study focused on reach, impacting reach could also impact effectiveness. The Weigh and Win program is evidenced-based and already able to reach participants, as demonstrated in the evaluation of the program described above. However, could the addition of a Fitbit enhance the reach, and therefore impact the effectiveness of the program? It will be interesting to evaluate the effectiveness of the Fitbits on participant weight loss of those in the study. It will be particularly interesting to discover if those

who did accept and sync a Fitbit with the Weigh and Win program, have greater engagement with the program, and lose significantly more weight as a result.

Conclusions

This study is important because it is the first study evaluating the uptake of a wearable activity tracker in a community-, incentive-, and web-based weight loss program. This study reports preliminary findings of the larger study evaluating the effectiveness of adding a wearable activity tracker in a community-, incentive-, and web-based weight loss program. The results of this study will contribute to the larger study on effectiveness. Because 46% of participants accepted and synced a Fitbit, and were younger and weighed more, these participants could potentially be more engaged in the program, and therefore lose more weight as a result. Overall, the results of this study and the larger study on effectiveness will help our research practice partner, IncentaHealth, make a decision on implementing a wearable device into the Weigh and Win program. Results of this study could be beneficial for other “real world” community-, incentive-, and web-based weight loss programs that want to intervene to improve reach and representativeness of participants, as well as effectively impact weight loss while addressing public health impact.

REFERENCES

- Abrams, D. B., Orleans, C. T., Niaura, R. S., Goldstein, M. G., Prochaska, J. O., & Velicer, W. (1996). Integrating individual and public health perspectives for treatment of tobacco dependence under managed health care: a combined stepped-care and matching model. *Annals of Behavioral Medicine*, *18*(4), 290-304.
- Akers JD, Estabrooks PA, Davy BM. Translational Research: Bridging the gap between long-term weight loss maintenance research and practice. *Journal of the American Dietetic Association*. 2010;110(10):1511-1522.e3. doi:10.1016/j.jada.2010.07.005.
- Anderson, L. M., Quinn, T. A., Glanz, K., Ramirez, G., Kahwati, L. C., Johnson, D. B., ... & Katz, D. L. (2009). The effectiveness of worksite nutrition and physical activity interventions for controlling employee overweight and obesity: a systematic review. *American journal of preventive medicine*, *37*(4), 340-357.
- Bandura, A. (2001). Social cognitive theory: An agentic perspective. *Annual review of psychology*, *52*(1), 1-26.
- Bennett, G. G., Steinberg, D. M., Stoute, C., Lanpher, M., Lane, I., Askew, S., ... & Baskin, M. L. (2014). Electronic health (eHealth) interventions for weight management among racial/ethnic minority adults: a systematic review. *Obesity Reviews*, *15*(S4), 146-158.
- Burke, L. E., Wang, J., & Sevick, M. A. (2011). Self-monitoring in weight loss: a systematic review of the literature. *Journal of the American Dietetic Association*, *111*(1), 92-102.
- Butryn, M. L., Phelan, S., Hill, J. O., & Wing, R. R. (2007). Consistent self-monitoring of weight: a key component of successful weight loss maintenance. *Obesity*, *15*(12), 3091-3096.
- Carpenter, K.M., Lovejoy, J.C., Lange, J.M., Hapgood, J.E., & Zbikowski S.M. (2014). Out

- comes and Utilization of a Low Intensity Workplace Weight Loss Program. *Journal of Obesity*.
- Case MA, Burwick HA, Volpp KG, Patel MS. Accuracy of Smartphone Applications and Wearable Devices for Tracking Physical Activity Data. *JAMA*. 2015; 313(6):625-626.
- Conroy, M. B., Yang, K., Elci, O. U., Gabriel, K. P., Styn, M. A., Wang, J., ... Burke, L. E. (2011). Physical Activity Self-Monitoring and Weight Loss: 6-Month Results of the SMART Trial. *Medicine and Science in Sports and Exercise*, 43(8), 1568–1574.
- Comstock, Jonah. (2016). WebMD survey: Millennials and seniors are least likely to use wearable fitness trackers. *Mobihealthnews*. <http://mobihealthnews.com/content/webmd-survey-millennials-and-seniors-are-least-likely-use-wearable-fitness-trackers>. April 12th, 2016.
- Donnelly, J. E., Blair, S. N., Jakicic, J. M., Manore, M. M., Rankin, J. W., & Smith, B. K. (2009). American College of Sports Medicine Position Stand. Appropriate physical activity intervention strategies for weight loss and prevention of weight regain for adults. *Medicine and science in sports and exercise*, 41(2), 459-471.
- Dzewaltowski, D. A., Estabrooks, P. A., & Glasgow, R. E. (2004). The future of physical activity behavior change research: what is needed to improve translation of research into health promotion practice?. *Exercise and sport sciences reviews*, 32(2), 57-63.
- Evenson, K. R., Goto, M. M., & Furberg, R. D. (2015). Systematic review of the validity and reliability of consumer-wearable activity trackers. *International Journal of Behavioral Nutrition and Physical Activity*, 12(1), 1-22.
- Ferguson, T., Rowlands, A. V., Olds, T., & Maher, C. (2015). The validity of consumer-level, activity monitors in healthy adults worn in free-living conditions: a cross-sectional study. *International Journal of Behavioral Nutrition and Physical Activity*, 12(1), 42.

Fitbit, <http://www.fitbit.com>. December 9th, 2015.

Franz, M. J., VanWormer, J. J., Crain, A. L., Boucher, J. L., Histon, T., Caplan, W., ... & Pronk, N. P. (2007). Weight-loss outcomes: a systematic review and meta-analysis of weight-loss clinical trials with a minimum 1-year follow-up. *Journal of the American Dietetic Association*, 107(10), 1755-1767.

Fryar, C. D., Carroll, M. D., & Ogden, C. L. (2015). Prevalence of Overweight, Obesity, and Extreme Obesity Among Adults: United States, 1960–1962 Through 2011–2012.

Fritz, T., Huang, E. M., Murphy, G. C., & Zimmermann, T. (2014, April). Persuasive technology in the real world: a study of long-term use of activity sensing devices for fitness. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 487-496). ACM

Glasgow, R. E., Klesges, L. M., Dzewaltowski, D. A., Bull, S. S., & Estabrooks, P. (2004). The future of health behavior change research: what is needed to improve translation of research into health promotion practice? *Annals of Behavioral Medicine*, 27(1), 3-12.

Glasgow, R. E., Klesges, L. M., Dzewaltowski, D. A., Estabrooks, P. A., & Vogt, T. M. (2006). Evaluating the impact of health promotion programs: using the RE-AIM framework to form summary measures for decision making involving complex issues. *Health Education Research*, 21(5), 688-694.

Gustafson, A., Khavjou, O., Stearns, S. C., Keyserling, T. C., Gizlice, Z., Lindsley, S., ... & Poindexter, P. (2009). Cost-effectiveness of a behavioral weight loss intervention for low-income women: the Weight-Wise Program. *Preventive medicine*, 49(5), 390-395.

Harden, S. M., Gaglio, B., Shoup, J. A., Kinney, K. A., Johnson, S. B., Brito, F., ... & Glasgow,

- R. E. (2015). Fidelity to and comparative results across behavioral interventions evaluated through the RE-AIM framework: a systematic review. *Systematic reviews*, 4(1), 1.
- Harvey, J. R., & Ogden, D. E. (2014). Obesity treatment in disadvantaged population groups: Where do we stand and what can we do?. *Preventive medicine*, 68, 71-75.
- IncentaHealth, <http://www.weighandwin.com>. December 6th, 2015.
- Jensen, M. D., Ryan, D. H., Apovian, C. M., Ard, J. D., Comuzzie, A. G., Donato, K. A., ... & Loria, C. M. (2014). 2013 AHA/ACC/TOS guideline for the management of overweight and obesity in adults. *Circulation*, 129(25 SUPPL. 1).
- Jeffery, R. W., Thompson, P. D., & Wing, R. R. (1978). Effects on weight reduction of strong monetary contracts for calorie restriction or weight loss. *Behaviour research and therapy*, 16(5), 363-369.
- John LK, Loewenstein G, Troxel AB, Norton L, Fassbender JE, Volpp KG. Financial Incentives for Extended Weight Loss: A Randomized, Controlled Trial. *Journal of General Internal Medicine*. 2011;26(6):621-626. doi:10.1007/s11606-010-1628-y.
- Kahn, LK., Sobush, K., Keener, D., Goodman, K., Lowry, A., Kakietek, J., & Zaro, S. (2009). *Recommended community strategies and measurements to prevent obesity in the United States* (Vol. 58). US Department of Health & Human Services Centers for Disease Control and Prevention.
- Krauss, R. M., Eckel, R. H., Howard, B., Appel, L. J., Daniels, S. R., Deckelbaum, R. J., ... & Lichtenstein, A. H. (2000). AHA dietary guidelines revision 2000: a statement for healthcare professionals from the Nutrition Committee of the American Heart Association. *Circulation*, 102(18), 2284-2299.

- Kullgren JT, Troxel AB, Loewenstein G, et al. Individual vs. Group-Based Incentives for Weight Loss: A Randomized, Controlled Trial. *Annals of internal medicine*. 2013;158(7):505-514. doi:10.7326/0003-4819-158-7-201304020-00002.
- Lee, J., & Finkelstein, J. (2013). Activity trackers: a critical review. *Studies in health technology and informatics*, 205, 558-562.
- Lee, J. M., Kim, Y. W., & Welk, G. J. (2014). TRACK IT: Validity and utility of consumer-based physical activity monitors. *ACSM's Health & Fitness Journal*, 18(4), 16-21.
- Lewis, Z. H., Lyons, E. J., Jarvis, J. M., & Baillargeon, J. (2015). Using an electronic activity monitor system as an intervention modality: A systematic review. *BMC public health*, 15(1), 585.
- Meyer, J., & Boll, S. (2014). Digital Health Devices for Everyone!. *IEEE Pervasive Computing*, (2), 10-13.
- Michie, S., Abraham, C., Whittington, C., McAteer, J., & Gupta, S. (2009). Effective techniques in healthy eating and physical activity interventions: a meta-regression. *Health Psychology*, 28(6), 690.
- Michie, S., Richardson, M., Johnston, M., Abraham, C., Francis, J., Hardeman, W., ... & Wood, C. E. (2013). The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: building an international consensus for the reporting of behavior change interventions. *Annals of behavioral medicine*, 46(1), 81-95.
- Neuhauser, L. and Kreps, G. L. (2003) Rethinking communication in the E-health era. *Journal of Health Psychology*, 8, 7-23.
- NPD Group/Connected Intelligence Consumers and Wearables Report. (2016). Retrieved from:

<https://www.npd.com/wps/portal/npd/us/news/press-releases/2015/the-demographic-divide-fitness-trackers-and-smartwatches-attracting-very-different-segments-of-the-market-according-to-the-npd-group/>

Panel, N. O. E. I. E. (1998). Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults. NHLBI. <http://www.ncbi.nlm.nih.gov/books/NBK2003/>

Patel MS, Asch DA, Volpp KG. Wearable Devices as Facilitators, Not Drivers, of Health Behavior Change. *JAMA*. 2015; 313(5):459-460.

Physical Activity Guidelines Advisory Committee. (2008). Physical activity guidelines advisory committee report, 2008. Washington, DC: US Department of Health and Human Services, 2008, A1-H14.

Pronk, N. P. (2003). Designing and evaluating health promotion programs. *Disease Management & Health Outcomes*, 11(3), 149-157.

Rooksby, J., Rost, M., Morrison, A., & Chalmers, M. C. (2014, April). Personal tracking as lived informatics. In Proceedings of the 32nd annual ACM conference on Human factors in computing systems (pp. 1163-1172). ACM.

Saperstein, S. L., Atkinson, N. L., & Gold, R. S. (2007). The impact of Internet use for weight loss. *Obesity reviews*, 8(5), 459-465.

Sasaki, J. E., Hickey, A., Mavilia, M., Tedesco, J., John, D., Kozey Keadle, S., & Freedson, P. S. (2014). Validation of the Fitbit Wireless Activity Tracker® for Prediction of Energy Expenditure. *J Phys Act Health*.

Stearns, M., Nambiar, S., Nikolaev, A., Semenov, A., & McIntosh, S. (2014). Towards

- evaluating and enhancing the reach of online health forums for smoking cessation. *Network Modeling Analysis in Health Informatics and Bioinformatics*, 3(1), 1-11.
- Swan, M. (2013). The quantified self: Fundamental disruption in big data science and biological discovery. *Big Data*, 1(2), 85-99.
- Tate, D. F., Finkelstein, E. A., Khavjou, O., & Gustafson, A. (2009). Cost effectiveness of internet interventions: review and recommendations. *Annals of Behavioral Medicine*, 38(1), 40-45.
- Thompson, W. R. (2015). "WORLDWIDE SURVEY OF FITNESS TRENDS FOR 2016: 10th Anniversary Edition." *ACSM's Health & Fitness Journal* 19(6).
- Trogon JG, Finkelstein EA, Hylands T, Dellea PS, Kamal-Bahl. Indirect costs of obesity: a review of the current literature. *Obes Rev*.2008;9(5):489–500.
- Tunis, S. R., Stryer, D. B., & Clancy, C. M. (2003). Practical clinical trials: increasing the value of clinical research for decision making in clinical and health policy. *Jama*, 290(12), 1624-1632.
- United States Department of Health and Human Services, Healthy People 2020. (2014, September 25). Social Determinants of Health. Retrieved from <http://www.healthypeople.gov/2020/topicsobjectives2020/overview.aspx?topicid=39>
- United States Department of Health Human Services, & United States Department of Agriculture. (2010). Dietary guidelines for Americans, 2010.
- Volpp, K. G., John, L. K., Troxel, A. B., Norton, L., Fassbender, J., & Loewenstein, G. (2008). Financial incentive-based approaches for weight loss: a randomized trial. *Jama*, 300(22), 2631-2637.

- Wang, J. B., Cadmus-Bertram, L. A., Natarajan, L., White, M. M., Madanat, H., Nichols, J. F., ... & Pierce, J. P. (2015). Wearable Sensor/Device (Fitbit One) and SMS Text-Messaging Prompts to Increase Physical Activity in Overweight and Obese Adults: A Randomized Controlled Trial. *Telemedicine and e-Health*, 21(10), 782-792.
- Wang, Y. C., McPherson, K., Marsh, T., Gortmaker, S. L., & Brown, M. (2011). Health and economic burden of the projected obesity trends in the USA and the UK. *The Lancet*, 378(9793), 815-825.
- Weinstein, P. K. (2006). A review of weight loss programs delivered via the Internet. *Journal of Cardiovascular Nursing*, 21(4), 251-258.