Smart Wearables: Utilizing Persuasive Devices to Reduce Sedentary Time

by

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Abstract

This research studied the effectiveness of alerts from smart wearables on health. Topics include sedentary behavior, smart wearables, and behavior modification. Building on work that shows alerts to be effective in various health and medical circumstances, this study asked participants to wear a device, specifically an Apple Watch, to measure a renewed area of interest in health research - effects of sedentary time on health. Metrics studied included a measure of sedentary time, calories, exercise, and steps, which were recorded first without and then with alerts prompting the wearer to break up long stretches of sedentary time. Both quantitative and qualitative findings are discussed, including the finding that an increase in the number of steps taken was correlated to the use of alerts reminding wearer to break up long stretches of sedentary time.

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Chapter 1: Introduction

Modern uses of wearable digital technology gained popularity in the 1970s, when mass production of smaller and advanced microchips began. Some of the better-known uses were the calculator watch, the Sony Walkman, and hearing aids. More recently with continued advances in both hardware and software, wearables have become increasingly smart. Smart wearables are largely considered to be wearable technology that can transmit and receive data. Modern smart wearables often require a connected device, often a nearby cellular phone, to gain internet access for data transmission. In the United States an early major consumer instance of smart wearable technology was the shoe insertable Nike+ iPod fitness tracker, which gave way to a plethora of fitness trackers, including belt and wrist wearable devices. Since the beginning of smart wearables, health and fitness has been a major reason for consumers to own smart wearables. As devices have matured, other functions have been added. Many smart wearables now connect with a phone to send and receive communications or alerts, essentially becoming an extension of the phone. Contemporary smart wearables have largely coalesced around the form of wrist wearable devices, which have a primary function of either telling time (e.g. Apple Watch, Android Wear) or counting steps (e.g. Fitbit). Other smart wearables take the form of eyeglasses, jewelry, or clothing.

This study focuses on a specific device, the Apple Watch, due to its relative success and prevalence among smart wearables and due to functionality offered. As with many smart wearables, this device must be wirelessly connected to a phone for it to provide full functionality. This device was first released in April 2015, and has become the best selling smart wearable in the world. The company that produces these devices, Apple Inc, does not disclose sales data, but analysts estimate that 12 to 13 million Apple Watches were sold in the device’s first year, and that Apple Watches accounted for over 60% of all smartwatch sales in 2015 (Darmwal, 2015).

The software used for this study are the Health and Activity applications developed by Apple, which are pre-installed on both the iPhone and the Apple

Watch. These applications track and store various health metrics and can be set up to alert the wearer to be active or to remember to exercise. These applications' version updates are connected to the operating system version updates. This study was conducted using Apple watchOS version 2.2.1 for the Apple Watches and iOS version 9.3.2 for the connected iPhones. These were the latest operating system versions available at the beginning of this study.

In the time it took to conduct this study, smart wearable technology has continued to increase in market proliferation. While there are many reasons for people to acquire and continue to use smart wearable devices, health is one major area of interest especially for having additional motivations to stay fit (Lazar, Koehler, & Tanenbaum, 2015). The goal then is behavior change, although many devices fail in assisting the wearer to create a new habit or learned behavior of incorporating healthy practices into daily life without the continued assistance of the technology (Castaño, Bynum, Andrés, Lara, & Westhoff, 2012; Dayer, Heldenbrand, Anderson, Gubbins, & Martin, 2013). This means that the device continues to play a key role in the behavior change. Even so, there are varying degrees of metrics tracked and persuasions offered by health tracking devices. Some devices, like popular wrist wearable step counters, simply track steps to give the wearer a point to compare and aid self-motivation. Smarter devices may also include opportunities for social interaction and notifications to increase motivation. Specifically the Apple Watch includes a collection of health applications to track workouts, steps taken, heart rate, and calories burned much like other wearables. In addition, it includes the ability to track sedentary time and offers alerts to encourage movement when the wearer has been sedentary for too long. Persuasive technology's effects on reducing sedentary time are the major focus of this study. This study predicts that persuasive technology can reduce long stretches of sedentary time, which will also lead to increases in other healthy behaviors.

Chapter 2: Literature Review

Topic Introduction

This review of literature first considers the evidence for participating in physical activity, and will show physical activity to be a proven, important component in a person's overall health and in reducing susceptibility to certain illnesses and chronic conditions. As scientific evidence has evolved, so have recommendations on what type of activities and how much participation is needed. Recent medical studies have considered the detrimental effects of long stretches of sedentary behavior and how connected that might be to participation in physical activity. Behavior modification techniques are necessary in order to initiate any change, which could create positive outcomes in health; while habit formation creates a situation where long-term change can thrive. Finally, it is important to look at the role of persuasive technology and how it can be utilized in effort to encourage healthy behavior changes

Healthy Behavior - Why Induce Change

Medical professionals have long recommended their patients exercise or participate in physical activity of some kind. While recommendations have varied over time, certain minimum levels of activity have long been shown to produce health benefits including decreased prevalence of several heart and circulatory issues; decreasing risk of stroke, some cancers, type 2 diabetes, and other adverse health outcomes; and finally increasing bone, mental, and emotional health (Powell, Paluch, & Blair, 2011; Wannamethee & Shaper, 2001; U.S. Center for Disease Control and Prevention [U.S. CDC], 2015; U.S. Department of Health and Human Services [HHS], 2008; World Health Organization [WHO], 2010).

Studies in the past have shown various recommendation to be best, however in recent years recommendations for most adults have coalesced around two equatable options (note: recommendations for children and elder adults vary). The first option is most adults should participate in 75 minutes of vigorous-intensity activity per week, which is sometimes stated as 25 minutes of this type of activity, three times per week. The second option sets a goal of 150 minutes per week of moderate-intensity activity, which is sometimes stated as 30 minutes, five times a week (Haskell et al., 2007; Powell et al., 2011; U.S. CDC, 2015; U.S. HHS, 2008; Wannamethee & Shaper, 2001; WHO, 2010). The moderate-intensity option has become the more popular recommendation, especially as evidence has strengthened over time to show a diminishing return of health benefit with added intensity of exercise or with increased length of time (Brown, Bauman, & Owen, 2009). Moderate activity is also more achievable than vigorous level activity for more people, even those who have not been active in some time. While this study focuses on aerobic activity, an additional recommendation for optimal health includes muscle-strengthening activities twice per week for all major muscle groups (Haskell et al., 2007; Powell et al., 2011; U.S. CDC, 2015; U.S. HHS, 2008; Wannamethee & Shaper, 2001; WHO, 2010).

Vigorous-intensity activity has been defined as activity that substantially elevates the heart rate and has the exerciser breathing heavily and quickly. Running and playing organized sports like basketball would be included in this type of activity. Moderate-intensity activity elevates heart rate, increases breathing, and will cause most people to begin sweating. This type of activity can include briskly walking, and even certain housework like gardening or using a push mower. It is important to note mild-intensity or light activities do not substantially raise the heart rate or alter breathing rhythm and includes slowly walking, standing, and lifting lightweight objects (Haskell et al., 2007; Powell et al., 2011; U.S. CDC, 2015; U.S. HHS, 2008; Wannamethee & Shaper, 2001; WHO, 2010).

Latest Healthy Behavior Trends - Reduce Sedentary Time

While studies have shown a threshold of weekly or daily activity is important for remaining healthy, including exercise into the daily or weekly routine may not be the exclusive activity requirements one should consider. There is a renewed focus on sedentary behavior that began with some of the earliest studies on physical activity and health, which took a concerned look at occupational sitting (Brown et al., 2009). More recently, "studies using sophisticated molecular biology and medical chemistry methodologies have found that exercise and inactivity change the body in different unique ways" and therefore each require consideration (Hamilton, Healy, Dunstan, Zderic, & Owen, 2008). Other recent studies have shown too much sedentary time, particularly long stretches of sedentary time, can decrease a person's health (Dunstan, Howard, Healy, & Owen, 2012). This decrease in health has proven true even for otherwise healthy individuals, even those who complete recommended daily physical activity (Ford and Caspersen, 2012). This bolsters the argument for offering a specific recommendation on the reduction of sedentary time in addition to recommendations on minimum activity participation. The Ford and Caspersen (2012) and the Hamilton et al. (2008) studies are further strengthened by Pereira, Ki, and Power (2012) who also suggested sedentary behavior is an independent metric from physical activity, and to increase health it is important to be both physically active the prescribed amount each week, and to reduce long sedentary periods. Even a few minutes of mild-intensity activity like standing or slowly walking a few steps helps to break up long stretches of sedentary time, allowing a person to reap health benefits (Dunstan, et al., 2012).

Spending long stretches of time in a sedentary state has a high correlation to reduced cardiovascular health, especially when those long stretches include TV viewing (Crichton & Alkerwi, 2014; Pereira et al. 2012). Interestingly looking at several cardiovascular and metabolic health measures, sedentary time during work, especially sitting at a computer for work, did not exhibit as strong of a correlation to reduced health as did sedentary time during leisure time away from work, specifically TV viewing (Pereira et al. 2012). De Rezende, Lopes, Rey-López, Matsudo, & do Carmo Luiz, (2014) conducted an overview of several studies looking at health and sedentary time. In the studies they reviewed, they found a clear relationship existed between type 2 diabetes and sedentary time and also with cardiovascular health and sedentary time, but not between sedentary time and either cancer, obesity, or weight loss. So while breaking up sedentary time may play an important part for some health risk factors, it may not for others.

There is some divergence in the literature in regards to the importance of reducing long stretches of sedentary time. According to Proper, Singh, Van Mechelen and Chinapaw, (2011):

> Sedentary behavior may be an important determinant of health, independently of physical activity. However, the relationship is complex because it depends on the type of sedentary behavior and the age group studied. The relationship between sedentary behavior and many health outcomes remains uncertain; thus, further studies are warranted. (p. 1)

This overview of studies on sedentary behavior found no correlation between sedentary time and weight or obesity. Note there is minimal overlap in the studies included in the Proper et al. (2011) review and those include in the later de Rezende et al. (2014) review. Both found a lack of correlation between sedentary time and either obesity or weight. It is still important to prove or disprove a correlation between sedentary time and other health factors, especially cardiovascular health, but it increasingly appears neither obesity nor weight is correlated to long stretches of sedentary time.

Another potential contradiction is the Stamatakis, Hamer, Tilling, & Lawlor (2012) study, which found sedentary time and cardiovascular risk factors were correlated only when measured by self-report, especially for sedentary time spent in TV viewing. They acknowledge further study is needed to see if TV viewing is perhaps associated with other behaviors, for example with unhealthy eating, which have an effect on cardiovascular health. It is also possible that accelerometer data, also used in this study, was simply less accurate than self-reporting. The self-reporting survey split TV viewing, leisure sedentary time, from other sedentary time like sitting at a desk at work; however, the accelerometer data lumped TV viewing with all other sedentary time both at leisure and work, making it an inequitable comparison. Since other studies have shown sedentary time at work may have different effects on the body than leisure sedentary time, and TV sedentary time especially has a particularly distinct correlation to adverse health indicators, it is likely that in the Stamatakis et al. (2012) study the self-report was indeed more accurate than the mechanically collected data. It could therefore be considered that not all sedentary time is unhealthy, especially sedentary time spent in focused thought.

Even with a bit of uncertainty, and possible disproving a correlation between sedentary time and certain health indicators, sedentary time is emerging, perhaps more correctly re-emerging, as an important health factor for researchers and medical practitioners. Enough studies have shown correlation of particular types of sedentary time to certain important health indicators to offer reason enough to consider it for healthful living.

Behavior Modification and Habit Formation - How to Induce Change

It is important to first consider how behavior can be modified and how habits are formed before attempting. The following sections discuss some of the better-known theories.

Behavior Modification

There are various theories and models concerning behavior modification, which are helpful to consider when thinking about how persuasive technology should assist in behavior modification. Perhaps some of the best recognized are the Goal-Setting Theory, Self-Determination Theory, Transtheoretical Model, and the Behavior Model.

The Goal-Setting Theory is described by Locke and Latham (2002) as primarily useful in work settings; however, it has crossover beyond that setting and is important to consider with behavior modification for health. This theory says behavior change can be initiated when someone sets a goal. A proper goal should be specific, have the right amount of difficulty, and incorporate subgoals. Specific goals help the person working towards them to know explicitly what to work towards. Degree of difficulty should be considered because if a goal is too easily obtained it could lead to a loss of interest, but if the goal is too difficult it might induce hopelessness. Subgoals allow small victories towards the main goal, which can help drive motivation to achieve other subgoals and eventually the main goal. Other important factors include the need to regularly evaluate a goal and its subgoals and to have buy-in from the person working towards the goal, even if another person or entity is setting the goal (Locke & Latham, 2002).

Goal setting presents a whole area of study in itself. One important consideration is who should set a goal. One three month long in situ study about goal setting for health discovered most of the participants preferred to set health goals on their smart devices for themselves (Consolvo, Klasnja, McDonald, & Landry, 2009). Even so, many devices and applications offer suggestions as a starting point, which the device user can then modify as desired. With the device and software used in this study, some goals are recommended by the device and then set by the user, while other health goals are set by the watch and cannot be changed by the user.

Another way to look at behavior modification is through the lens of Self-Determination Theory. “Humans have an inclination toward activity and integration, but also have a vulnerability to passivity" (Ryan & Deci, 2000, p 76). This intrinsic motivation is an internal motivation. It has the ability to propel people to stretch their bounds mentally and physically; however, when intrinsic motivation is not present, indifference can set it. Extrinsic motivation on the other hand, is motivation expecting some outcome other than pure enjoyment of the activity itself. Ryan and Deci (2000) listed a range of varying degrees of extrinsic motivation, including “personal importance” and “synthesis with self,” which both approach intrinsic motivation but have outcomes besides pure enjoyment. Genuine intrinsic motivation, according to the Self-Determination Theory, is only achieved when the person has true interest, enjoyment, or inherent satisfaction with the activity, and no separable outcomes. Separable outcomes would even include losing weight to look or feel better or training for the purpose of running a marathon. Therefore according to this theory, health and fitness goals are likely often motivated extrinsically at least in part, although some people may truly enjoy an activity in and of itself that also happens to offer health and fitness benefits. This theory follows that autonomous regulation and social desires of belonging or connectedness to others are both important for continued motivation. Intrinsic and extrinsic motivations alike can be assisted with supports like social elements. While some activity trackers allow social interaction, usually in the form of competition, the device used did not, at the time of the study, offer an easy way for social connectedness with health goals or the metrics tracked.

Another way of looking at behavior change is with the Fogg Behavior Model, which states a behavior requires a trigger together with ability and motivation (Fogg, 2009a). "All three factors must be present at the same instant for a behavior to occur." For many people the ability is present, but health goals may require motivation or a trigger. It can be difficult to remember to devote time for health goals until working towards them becomes habitual, which likely means the trigger has become embedded into one's daily routine. Examples of an imbedded trigger would be when waking up triggers time to go for a run before work, or when lunchtime triggers time to go to the gym. In order to find a trigger and motivation for healthy behavior changes, some people turn to assistance from smart wearables. Triggers with smart wearables are usually accomplished through reminder alerts or simply displaying metrics within easy view. People are motivated in various ways, and smart wearables offer various motivational tools. For example notifications that offer encouraging words; ability to compare performance metrics to compete with current goals, past results, or with friends; and with achievements, the ability to earn badges or other types of rewards.

The final behavior change model addressed here is the Transtheoretical Model, described by Prochaska, DiClemente, and Norcross (1992), which is concerned with the stages of change. Which stage a person is in will determine the best process to modify behavior at a given time. This model mostly relates to addictive behaviors, but considering inactivity and unhealthiness can be like addictive behaviors in that it is difficult to modify them, it is important to consider this model in how a person can move from inactivity to healthy levels of activity. Following the steps described, one will contemplate change, prepare for change, perform actions towards change, maintain change, and finally terminate the addiction or undesired behavior (Prochaska et al., 1992). In the case of health, someone might contemplate change when their doctor warns them about the need to increase healthy activity. He or she might prepare for change by signing up for a gym membership or purchasing new running shoes. The action might include taking that first fitness class or short run. Maintaining change, by continuing to participate in healthy activities might be a weekly struggle, especially at first while the new routine is established. This model also allows for movement in both directions through the stages.

Habit Formation

Creating habits goes further than changing behavior once or even several times. A person who changes can always regress back to a previous behavior as shown in the Transtheoretical Model. A habit is a more lasting change and helps keep a person from regressing. Still thinking about the Transtheoretical Model, a habit would likely begin in the maintenance stage. With the Self-Determination Theory, a habit might be formed when the exercise moves from a completely extrinsic motivation, like doctor's order, to a less extrinsic motivation, like feeling better and healthier when exercising. In the Fogg Behavior Model, a habit might be formed when there is a reliable trigger. Unfortunately if a device supplies the trigger, when the device is taken away, the trigger is taken as well. Whether or not the device becomes an integral part of the habit, it is important to understand habit formation. It is unfortunate most persuasive devices do remain a necessary part of the equation for sustained behavior change (Stawarz, Cox, & Blandford, 2015), which means no meaningful, autonomous habit formation occurres with the assistance of most devices. This is good news to device makers who want buyers to continue use their device, but it is not so good for a buyer who either forgets to wear the device or decides to discontinue wearing the device.

Consider that behaviors can be either actions or responses. Actions are known, conscious, purposeful, rational behaviors. Responses, also referred to as habits, are automatic and induced by a trigger (Dickinson, 1985). Habit begins as a controlled conscious action, but through certain training or practice can become automatic over time. According to Dickinson (1985), turning an action into a habit requires a strong behavior-reward correlation with little or no reward suppression in the early stages. This is done by offering a reward based on a ratio of behaviors performed. For a health application, it could be an encouraging alert for completing a goal for the day or it could be a badge for taking 10,000 steps each day for a week. Once the reward is correlated to the action, the relationship must become suppressed, meaning the reward must become less predictable in order to distance the relationship in the consciousness. The two ways of accomplishing that, as described by Dickinson (1985), are through overtraining, rote repetition, or through first establishing a correlation of action to reward to induce performance, then transitioning to a random interval schedule.

Persuasive Technology and Health

Wearers use health systems on smart devices to help them modify their behavior. Devices often offer persuasion with notifications, as described in previous sections. Looking at notifications deeper, research shows smart device notifications that are clicked on, are typically clicked on within 30 seconds (Shirazi, et al., 2014). While this means they can be disruptive, it also means they are good ways to remind or even persuade the device user to take an important action, like working towards health goals. Smart devices already claim some success in health contexts, specifically with medication adherence. In one study, adherence was increased compared to the control group by sending educational texts about a specific medication prescribed to patients; however, the improved adherence did not remain long-term after the text messages were discontinued (Castaño et al., 2012). Dayer et al. (2013) similarly found medication adherence applications do not promote long-term improvements and they were most beneficial to those with unintentional goal nonadherence. The Castaño et al. (2012) and Dayer et al. (2013) studies reiterate the habit formation claim of the Stawarz et al., (2012) study, namely no meaningful autonomous habit change occurs for a person when utilizing smart devices to assist in habit change because the device remains an essential part of the equation.

While benefit to goal adherence may not last after the motivation and trigger from the smart device are removed, it is possible to help encourage continued use of a smart device or wearable in order to continue the desired behavior change. According to Lazar et al. (2015), to accomplish this it is important to encourage routines, to minimize maintenance worries like charging, and appeal to wearers' identity through marketing. It is also important to process or explain raw data, provide feedback so users don't have to make the conscious decision to look at the device, and offer coaching especially for more difficult goals or when wearers may not have the knowledge, skills, and ability needed (Lazar et al., 2015). A device that adheres to these standards is more likely to be worn long-term, increasing the likelihood of a wearer reaching set health goals.

BJ Fogg (2009b) offers another lesson on how to create successful persuasive technology, concluding it is important to choose a simple target behavior, find a receptive audience, and find what prevents the target behavior. In the case of decreasing long stretches of sedentary behavior, the major focus of this study, the lack of a well timed trigger may be the missing element, since it is easy to lose track of time during either leisure or work related sedentary activity. Reminding a wearer to stand or move around for a few minutes each otherwise sedentary hour is a simple target behavior. A healthy and health conscious device user will likely be a ready and receptive audience.

Another important consideration - a quickly glanceable display helps users evaluate progress towards their fitness goals (Consolvo et al., 2008). The Apple Watch offers quick glance health rings, which fill in as the wearer reaches the goal, making it easy for wearers to see percentage of progress at a glance. In another study Consolvo, Everitt, Smith, and Landry (2006) informed that successful persuasive technology gives users credit, provides personal awareness, considers practical constraints, and offers a social element. The Apple Watch and Activity applications provide awareness with the Activity ring watch face widget. The rings fill in to show how much work towards the goal wearers have made. It can also be set to alert when the wearer has met each goal for the day, to offer badges for goals met, and to display an end of the week review to give users credit for goals met. Practical constraints are accounted for in that the wearer can turn off alerts for the remainder of the day, if needed, easily from the notification itself. The only element lacking with the Apple Watch system at the time of this study is a robust social element, although Apple has made some updates in this area with the latest software update, which was released after this study was conducted. Persuasive technology should not give too many notifications or ones that can be negatively perceived, should offer social accountability, and should make device use as effortless as possible (Dennison, Morrison, Conway, & Yardley, 2013).

Chapter 3: Research Methods

Participants

Fourteen participants were recruited for a four-week, in situ, within-subjects study. Participants were found through snowball sampling through participants who knew other people who owned an Apple Watch. Unfortunately there were four participants who did not successfully complete the study. One participant failed to submit any requested data at the end of the study, including answering post-study survey questions. This participant was not included in any research analysis. A second participant failed to submit part of the requested health data at the end of the study. A third participant had a technology issue and came away with no usable health data collected, but did complete both the pre and post-study survey with valuable information for qualitative results. Finally a fourth participant didn't wear the watch on several consecutive study days. Ultimately 10 participants had data fully included in this study, including the quantitative portion of analysis. Where it makes sense, three of the other four participants who offered survey data or substantial partial data are also included in the qualitative portion. To alleviate confusion in discussion the analysis will note how many participants were included for each point of discussion.

Participants were required to currently own and have been using an Apple Watch paired with an Apple iPhone for at least 1 month prior to the start of the study. Most participants (11 of 13) had been wearing their device for over 3 months. Two of the participants with fully included data had owned their device less than three months prior to the start of the study. All of the 13 participants had been wearing their smart wearable for less than 1 year. At the beginning of this study the watch had only been on the market for 13 months and was in the first generation, so all participants could be considered early adopters.

The 10 fully included participants were six males and four females, between the ages of 30 and 45, and from the Baltimore/Washington metro area. The whole group of 13 included seven males, six females, between the ages of 30 and 45, and mostly from the Baltimore/Washington metro area (11 of 13). The other two were from the Southeastern United States.

Participants' occupations varied: nurse, physical trainer, education, IT, PR, and tax lawyer were among the mix. This meant there were some who were more likely than others to be on their feet for long periods during work hours. Most participants described themselves as either sitting or being sedentary for long periods during their workday. Six of 12 said they spend most or all of their work day sitting, while only two participants described themselves as active or on their feet most of their work day. Participants self-reported their activity levels as slightly higher away from work, with 4 of 12 considering themselves mostly active or on their feet when not at work. The rest of the participants considered themselves at least partially active. No participants self-described as sitting or sedentary most or all times while away from work, citing housework, organized sports, outdoor activity, and workouts, which helped keep them active. Since these activity levels were self-reported and in person, it is possible there is some illusory superiority bias. However because these participants are relatively young and health conscious adults who are motivated to stay fit, and because they only had three levels to choose from in the survey, their self-reports of being somewhat to fairly active are probably reasonable assessments, and are also not likely to cause any skew in data or analysis.

All participants self described as at least moderately motivated to stay fit, while 8 of 12 considered themselves highly motivated for fitness. To help substantiate this, participants were also asked about health tracking history. All study participants had been tracking health metrics with their watch prior to the study, with the top three metrics being Steps, then Calories, and then Stand Hours. Half of the study participants had owned and previously worn health-tracking devices before owning and wearing their Apple Watch. Fitbit and Jawbone were the most popular previously worn device brands from this set of participants. Many participants also cited health tracking as a major reason for purchasing the Apple Watch. Most participants were using health alerts prior to the study; the three participants (of 13) who were not currently using their device's health alerts, had still been tracking and reviewing health metrics, especially steps and workouts.

From the beginning participants were encouraged to have in-person connections with the researcher, especially for the pre-survey, the study setup, the mid-study settings changes, post-study survey, and data collection. Two of the 13 participants participated exclusively remotely. These two remote participants never met with the researcher in person; however, three others participated remotely for study setup, but were then able to meet in person for post-study survey and data collection. Any remote participation included the same script, survey questions, and setup language as those who met in person in order to decrease the likelihood of introducing additional variables or biases. Remote participation was done via video calls in every case but one, which was done over a voice call.

Study Setup

This study was designed with two objectives in mind. The first was to research the effect of alerts from the Apple Watch to remind a user to stand or become mildly active for a few minutes each hour to fulfill the goal of decreasing long periods of sedentary time. This objective was to further substantiate studies that have shown alerts made from various devices and made for a specific health goal increases the likelihood of completing the goal. The second objective was to see if alerts encouraging one particular healthy activity, reducing long stretches of sedentary time, would have an effect on other health metrics. This study predicted alerts initiated to decrease long stretches of sedentary time would be shown effective, and that in the process of working to complete the reduction of sedentary time goal, participants would advance other health goals.

The primary dependent variable of this study is a measure of participants' sedentary time - referred to here as Stand Hours. Other variables compared were Total Steps, Exercise Minutes, and Active Calories, which is also referred to as Move by the device used. To measure sedentary time, this study used the metric calculated by the Apple Watch called Stand, referred to in this study as Stand Hours, which is a measure of how many hours sedentary time was broken up with at least mild activity like standing or slowly walking. This goal is automatically set to 12 hours of broken sedentary time for the day, and the device wearer cannot change it. This is one of the key metrics followed by the Activity application and is the inner blue ring (see Figure 1). Total Steps is a basic step count similar to those measured on many other devices. This popular metric is a measure of how many steps were taken in a day. It is important to note here that wrist worn devices can miscalculate steps. For example if the wearer is hammering, each swing can be counted as a step taken, on the other hand if a wearer is riding a bike the action is so smooth a step will likely not be counted. It is also interesting to note, while this is a popular metric, Apple deemphasizes it for their watch in both ease of finding and in not allowing the user to set a goal or receive alerts for this metric. Exercise Minutes is a measure of time spent being at least moderately active. Exercise Minutes is the middle yellow ring on the Activity application and is set by the device to 30 minutes per day, which is actually 60 minutes per week more than

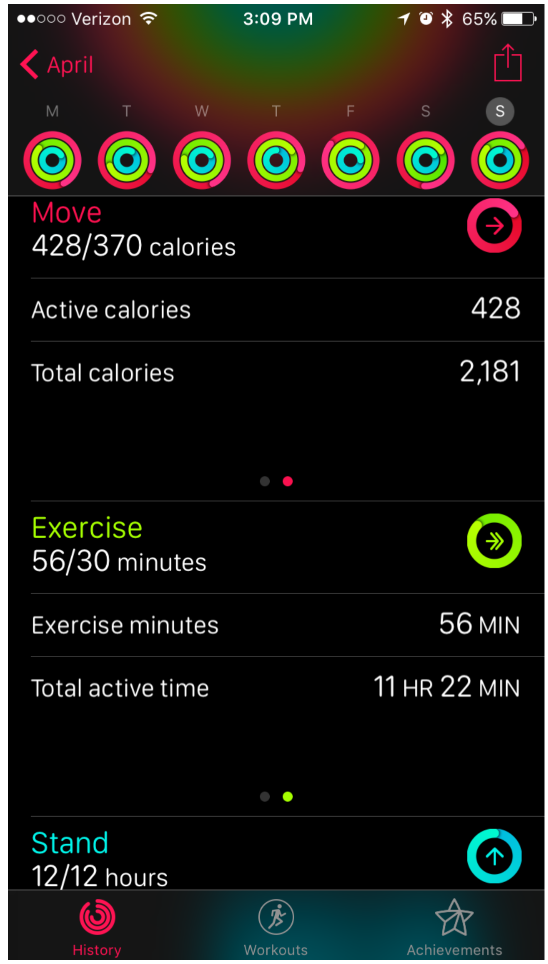

Figure 1: Activity application view as seen from an iPhone

national standards and suggestions made from research of 30 minutes of mild-intensity activity 5 times per week. Active Calories is a measure of how many calories were used by the body while being at least moderately active and does not include Resting Calories, calories used by the body during periods of inactivity or for regular life sustaining functions. Moderate activity includes activity like deliberately exercising, walking briskly, actively playing with children, or other movement that elevates the heart rate. The Active Calorie goal is originally set as part of the initial watch setup, and can be adjusted at any time since many factors go into how many calories are burned: gender, age, and weight. The watch offers a suggested goal and prompts the wearer to update their goal periodically based on these factors. All participants had an individual goal they had previously set and were comfortable with, so those were the Active Calorie goals used for the duration of this study. Active Calories is the red ring on the Activity application and called Move by the device.

Participant Setup

Participants were asked to wear their Apple Watch daily for four weeks, including two weeks with no notifications, followed by two weeks with health notifications. All participants were already used to wearing their device daily. Participants were generally aware this study was about smart wearables and health, but they were not informed of specifics like which metrics were important for the study. Study setup included ensuring each participant's watch was correctly paired to their iPhone and the included Activity application was initialized on both their watch and phone, set to collect and record data. Participants were asked to continue wearing their watch as they had before the study, for at least twelve hours a day.

First Half: Without Alerts

Prior to the first two weeks, participants were guided through turning off all health alerts and notification on both their watch and phone, and they were asked to refrain from checking health metrics, included not opening health tracking data on their watch or phone, not using an alternate application, and not wearing an alternate health tracking device while the study was ongoing. Participants who currently had the health application complication on their watch face were also guided through removing it. On the Apple Watch, so called complications give the wearer a view into an application from the watch face. It could be considered a widget. For the Activity application, the watch face complication, as seen in the lower left of Figure 2, shows percentage of goal completion for Stand Hours (blue), Exercise Minutes (green) and Active Calories (red) from inner circle to outer circle respectively.

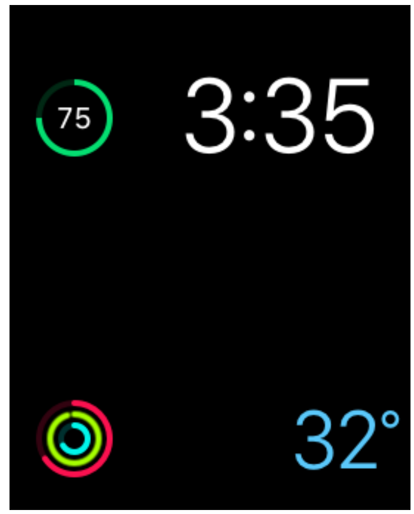

Figure 2: Sample Apple Watch face

By relieving participants of notification and easy access to viewing metrics, this study was able to get a baseline dataset for these fitness conscious individuals. To ensure the baseline was as unbiased as possible, the first week was set aside as a desensitization period and data collected for week one is not included in the analysis calculations. Similarly for the second two-week period when notifications were activated, the first week with alerts, week three overall in the study, is not included in the analysis calculations.

Second Half: With Alerts

At the start of the third week of the study, the beginning of the second two-week period, participants were instructed to and guided through turning on the built-in Activity application Stand alerts, Goal Completions, and Achievements. Stand reminders alert when the wearer has remained sedentary for the first 50 minutes of an hour. If the wearer has spent time doing a few minutes of at least mild-intensity activity, like standing or walking, during the hour then this notification will not alert. The Goal Completion alert notifies the wearer when they have reached the daily Active Calorie, Exercise Minute, or Stand goal. Unfortunately there is not a way to separate the three goal alerts in the Activity application on the Apple Watch, so all three had to be used to notify participants when they achieved their Stand goal for the day. If a participant completed one of the other two goals before completing the Stand goal, this would have the added effect of grabbing the participant's attention to focus on a health metric that was not the Stand metric one time in the day. It should be noted this introduces a minor possibility of slightly skewing results, but likely not enough to cause issues with the integrity of the study.

Post Study

Finally after the four-week study period was completed, all data was collected from the participants' paired iPhone, where the health metrics captured by the watch were being recorded. There was never a direct feed to the participant's information, either their watch or phone. After the study, participants were told about a 3rd party application, not associated with this study that was available for free on the Apple App Store. The application, DS Access, accessed some recorded health data with permission from the installer, and it compiled the data in a spreadsheet the participants could then submit. All participants who submitted data felt comfortable downloading and installing the application to collate part of their data for submission. The application did not include the ability to gather all desired data, so the remaining metrics, Stand Hours, Active Calories, and Exercise Minutes, were manually transcribed into a spreadsheet. Having to manually transcribe some of the data did introduce a chance for transcription error for those metrics.

Only week two and week four data are included in this analysis since week one and week three were desensitizing periods. So the study structure was thus: week one, no alerts active but no data used in analysis; week two, no alerts active and data included in analysis; week three, alerts active but no data used; week four, alerts active and data included in analysis.

Chapter 4: Discussion of Findings

Both quantitative and qualitative findings were made in this study. Quantitative analysis included only the ten participants that successfully completed the study and submitted all the requested data. Qualitative analysis also included three of the other four participants that offered partial data. This section further describes the details of the findings of this study.

Quantitative Findings

Quantitative analysis includes only the ten participants who completed the study without missing more than one day of device wear over week two and week four, and who submitted all requested data recorded by their devices. Participant's daily data for each week were added together for a given metric. This was the week's total for that metric and that participant. For example, adding up the seven daily totals of Steps for each week for Participant 4 gives us 57,288 steps without alerts during week two, and 65,904 Steps Taken with alerts during week four. The weekly totals for week two and week four for each metric were compared for all participants in a paired t-test. Each metric measured showed an overall increase with the addition of Stand alerts. Recall the metrics examined were Stand Hours, Steps, Active Calories, and Exercise Minutes. Also recall this study's prediction was an increase of Stand Hours with the introduction of Stand alerts.

Stand Hours was the metric of primary importance for this study. The addition of Stand alerts increased Stand Hours by 8.21%, increasing participant's weekly mean Stand Hours from 81.6 hours of sedentary time broken up without Stand alerts to 88.3 hours with the reminders, an increase of 6.7 hours. The margin of error was 8.04 hours, and the p-value was 0.092 (see Table 1 for additional detail). While this does not meet the study requirements of 95% confidence, this does offer a strongly suggestive result. Unfortunately, this study cannot claim with a statistical significance that alerts can be used to reduce long stretches of sedentary behavior. The observed increase in Stand

Hours with the addition of alerts, the reasonably high level of confidence with only ten participants, and the proven effectiveness of alerts in other health contexts like medication adherence offers a substantial reason to examine this relationship further with a larger number of participants.

Table 1:

Stand Hours Without and With Alerts

Participant	Week 2 Total (without alerts)	Week 4 Total (with alerts)	Difference	Change
Participant 2	86	102	16	18.60%
Participant 3	76	111	35	46.05%
Participant 4	82	87	5	6.10%
Participant 6	74	81	7	9.46%
Participant 7	63	86	23	36.51%
Participant 8	77	76	-1	-1.30%
Participant 9	88	88	0	0.00%
Participant 10	92	74	3	3.26%
Participant 11	91	74	-17	-18.68%
Participant 12	87	83	-4	-4.60%
Mean	81.6	88.3	6.7	8.21%
SD	9.08	11.51		
Paired t-test: p = 0.092				

Steps Taken is the only metric to meet the threshold of being statistically significant with over 95% confidence. Participants on average took 15.96% more Steps during the week with Stand alerts activated, increasing the weekly mean Steps Taken from 49,567.79 to 57,477.86, an increase of 7,910.07 Steps. The margin of error was 14,681.19 Steps with a p-value of 0.010. Every metric had at least one participant record a decrease with the addition of Stand alerts, but Steps showed only a single participant decreasing the number of Steps Taken (see Table 2 for more detail). We can assert the

Steps metrics has a strong correlation to the Stand alerts. Regarding the secondary prediction of this study, this study can assert, even with a small sample size, a side effect of using alerts to break up sedentary time is an increase in other healthy activity, specifically taking more steps throughout the week.

Table 2:

Steps Taken Without and With Alerts

Participant	Week 2 Total (without alerts)	Week 4 Total (with alerts)	Difference	Change
Participant 2	45,139	60,544	15,405	34.13%
Participant 3	57,019	65,316	8,297	14.55%
Participant 4	57,288	65,904	8,617	15.04%
Participant 6	14,609	14,790	181	1.24%
Participant 7	64,087	75,964	11,877	18.53%
Participant 8	60,189	61,412	1,223	2.03%
Participant 9	6,714	91,387	24,673	36.895
Participant 10	49,517	58,092	8,575	17.32%
Participant 11	37,309	29,325	-7,984	-21.40%
Participant 12	43,807	52,043	8,237	18.80%
Mean	49,567.79	57,477.86	7,910.07	15.96%
SD	15,484.53	21,841.99		
Paired t-test: p = 0.010				

The other metrics observed for this study, Active Calories and Exercise Minutes, both showed an increase, but neither showed a statistically significant increase. Active calories increased by 9.26%, with two participants who experienced a decrease. The weekly mean increased from 2,722.42 to 2,987.58 an increase of 253.17 calories. The margin of error was 743.59 calories, and the p-value was 0.085. This correlation is below the threshold for statistically significance, but is still suggestive. See Table 3 for more detail.

Table 3:

Active Calories Without and With Alerts

Participant	Week 2 Total (without alerts)	Week 4 Total (with alerts)	Difference	Change
Participant 2	3,331	3,408	77	2.32%
Participant 3	4,140	5,466	1326	32.03%
Participant 4	2,848	3,085	237	8.31%
Participant 6	2,722	2,454	-789	-9.84%
Participant 7	2,203	3,292	1089	49.43%
Participant 8	1,842	1,968	126	6.83%
Participant 9	3,103	3,118	15	0.495%
Participant 10	3,395	3,515	120	3.53%
Participant 11	1,835	1,500	-335	-18.28%
Participant 12	1,925	2,070	145	7.54%
Mean	2,734.41	2,987.58	253.17	9.26%
SD	778.70	11,110.23		
Paired t-test: p = 0.085				

Exercise minutes increased by 11.09%. The weekly mean for all participants increased from 211.9 minutes spent on moderate intensity activity, up to 235.4, an increase of 23.5 minutes in the week with alerts. The margin of error was 110.44 minutes and the p-value was 0.132. This correlation was also below the threshold for statistically significance, but similarly suggestive. See Table 4 for more detail.

Table 4:

Exercise Minutes Without and With Alerts

Participant	Week 2 Total (without alerts)	Week 4 Total (with alerts)	Difference	Change
Participant 2	332	306	-26	7.83%
Participant 3	217	372	155	71.43%
Participant 4	365	371	6	1.64%
Participant 6	182	96	-86	-47.25%
Participant 7	116	172	56	48.28%
Participant 8	111	108	-3	-2.70%
Participant 9	473	512	39	8.25%
Participant 10	138	182	44	31.88%
Participant 11	39	46	7	17.95%
Participant 12	146	186	43	29.45
Mean	211.9	235.4	23.5	11.09%
SD	135.82	148.74		
Paired t-test: $p = 0.132$				

An interesting point here is that to record a Stand Hour, a wearer only needs to stand up for a couple of minutes or take a very short, even gentle paced walk, any mild-intensity activity that will slightly elevate the heart rate for about a minute or two. What may have been the case is when a participant received a Stand alert after a long stretch of sedentary time, they may have been motivated to do more than required. In fact, several participants remarked the Stand alert was often motivation to walk either to a water fountain or bathroom or some other location across their office or home when they wouldn't have otherwise. In this way an alert designed to break up long stretches of sedentary time with a few minutes of gentle activity may actually offer benefits normally associated with additional activity. This would be a great topic for further study. If this proved to be true, it would further increase the value of breaking up sedentary time.

Consider that research is beginning to show a need for both activity and breaking up long periods of sedentary time. A person can workout for an hour every day and then continue the remainder of the day in a mostly sedentary state. On the other hand, a person who breaks up sedentary time is not able to avoid some amount of activity, helping to fulfill both recommendations.

With the increased proliferation of smart watches even during the course of this study, and with increased proliferation specifically of the Apple Watch, which can measure long stretches of sedentary time and includes onboard Stand notifications, it should be much easier now to find a larger participant pool. Further study with a larger sample size would be required to prove the Stand alerts effectiveness for both breaking up sedentary time and helping to increase other health metrics with an increased confidence and decreased margin of error.

Qualitative Findings

Qualitative analysis may include data or partial data collected from 13 of the 14 original participants, including one participant who failed to submit all requested health metrics and including the one participant who had only survey data but no recorded health metrics due to a device malfunction.

During the post-study survey, participants reported their favorite health metric to track was Active Calories (7 of 13), then Steps (2 of 13). This mostly aligns but contrasts slightly with the pre-study survey where the most participants said they tracked these two metrics, but 8 of 13 participants said they tracked steps and 8 of 13 said they tracked Active Calories. So while many of this study's participants tracked steps prior to the study, they did not necessarily view it as their favorite metric. However, most who reported paying attention to Active Calories felt it was also their favorite metric to track. This study cannot offer an exact reason for why this would be the case, but it's possible this is due in part to the Apple Watch deemphasizing Steps, which makes them more difficult to view and track and impossible to alert for. Participant 14 said, “I wish steps were more visible.” It’s also possible that because the Active Calories metric has a direct equation to health, it offers a tangible number for how much can be eaten after exercise or how many pounds one should be losing, where steps are a little more abstract. With Steps Taken, more is generally better, and it does offer a point of comparison from one day to the next. However steps do not explain if the wearer has done enough to indulge in a 100-calorie snack today, or if the wearer is on track to lose weight. Participant 10 said, “I try to hit and exceed active calories to lose weight, but I don't care as much about other [metrics]."

Most participants (8 of 13) self-reported feeling alerts affected their day. Of these, all said the effects were positive. Three others said they felt the alerts did not affect their day because they have enough self-motivation; however, those three still said they liked that the alerts made them more aware of how they were doing throughout the day. Furthermore, all participants said they planned to continue using the health alerts after completing the study, including the participants who did not feel alerts affected their day and participants who did not utilize the alerts prior to joining this study. During the post-study survey these participants mentioned valuing the extra awareness.

Most participants (8 of 13) reported noticing between two and four Stand alerts each day. Three participants did not notice many during the week, but quite a few on the weekends. One participant, Participant 7 who described himself as being quite active and on his feet most of the time at work and at home, recalling having only a single Stand alert for all of week four. Enough data was collected, including device wear time in rounded up hours and number of Stand Hours achieved to know this is a reasonable possibility as long as he fulfilled each Stand Hour before getting an alert for it, which is also feasible with his active job. On the other hand, Participant 8, who also described herself as active both at work and at home, reported noticing about one or two Stand notifications per day on average throughout the week. Data shows she would have received at least seven alerts on Tuesday, when she wore the device for 16 hours, but only made nine Stand Hours. Each of the remaining hours worn, hours 10-16 of the day, would have alerted her to stand because she was short of the 12 Stand Hour goal. It's possible she didn't receive many other alerts throughout the week and averaged those seven to get to her reported one or two alerts that week. It's also possible she did not perceive some of the alerts, or either forgot about or was embarrassed to report having a day that she ignored so many alerts. The number of alerts received was not integral to the study, but it is important to be aware of possible self-reporting biases.

All participants reported ignoring at least some alerts to break up sedentary time. The given reasons for ignoring alerts was mostly due to being in the middle of important business at work, but one participant also cited ignoring Stand alerts while on a long commute. One extreme example of alert ignoring was Participant 3 who cited only ignoring two alerts all week, and both of those because they came during naptime. At the other end of the spectrum, Participant 12, who reported noticing more alerts than most other participants, also claimed to have "ignored 90% of the Stand alerts because I was busy or in the middle of something important." Interestingly, Participant 12 was one of only two whose Stand Hours actually decreased significantly during the week that alerts were activated. It is possible this was due in part to wearing his watch about 11% fewer hours on week four then week two. It is also worthwhile to consider the possibility of the alerts giving him the opposite effect, actually demotivated him. He mentioned during his post-study survey that when he missed responding to a couple of alerts while at work, he tended to give up on working toward his goals for the remainder of the day, because he felt he couldn't catch up. This aligns well with the Goal-Setting Theory, especially the importance of setting an achievable difficulty level for goals. It might serve Participant 12 better if he were able to adjust his Stand Hour goal down.

When they received an alert for completing their goal during the day, most participants (10 of 13) reported a feeling of accomplishment. Participant 2 said, "it feels like a complete day when I close all the circles." Participant 13 said, "it makes me feel accomplished because working full time, it is hard to achieve,"

Five participants didn't wear their watch on at least one of the four Sundays of the study, including the desensitizing weeks. Perhaps not so coincidentally, Sunday was also, on average, the day when metrics were recorded at lowest levels. Adding each day of the week over the four-week study, Sunday was most sedentary day of the week for nine participants, recording the fewest Stand Hours of any other day. Eight of 11 recorded their fewest Exercise minutes, 11 of 12 the fewest Active Calories and 8 of 12 their fewest Steps Taken, all on Sunday. Saturday and Friday came in very distant seconds as least active days.

Motivation levels of participants didn't seem to correlate with whether they experienced health metric increases or decreases when Stand alerts were added. Five of the seven who self-described as highly motivated experienced a decrease in at least one metric. Two of five who self-described as moderately motivated experienced a decrease in at least one metric. Participants experiencing a decrease of metrics with alerts did not have clear correlation with any other factor collected in this study, including gender, length of time owning their device, activity level at their job or in home life, or even how many times they self-reported having ignored the Stand alerts. It is possible there simply were not enough participants to notice potential trends in these areas.

Another area to consider is which participants decreased their metrics with the addition of alerts. Excluding minor changes of less than 5%, only four participants, Participants 1, 2, 6, and 11, measured decreases in at least one metric in the week with alerts. The single largest decrease in metrics was a 47.25% decrease in Participant 6's Exercise Minutes with the addition of alerts. A possible explanation is he had added physical activity, specifically working out at a gym, to his routine only a few weeks before this study began; however, he had a minor medical concern, which caused him to pause his workouts during week three of the study, a week not included in the analysis. Still after not working out for a week, he reported in his post-study survey that he found it difficult to get back into. This is the likely cause of such a large decrease. The next single largest decline was Participant 11, who had decreases of around 20% for each of three metrics: Active Calories, Steps, and Stand Hours. She was also the only participant to decrease in three metrics. Interestingly she increased her Exercise Minutes by nearly 18%, showing that these metrics can move independently of each other, and that the device wearer can increase activity level and still increase sedentary time in the same week.

Potential Conflicts

Several potential problems or issues were present and are important to consider. Transcription error introduces perhaps the largest potential for skewed results. Only some of the metrics collected were able to be collected directly from the device, others were manually transcribed from the device into a spreadsheet. All numbers were carefully checked over to help combat error to the data.

Additionally the survey portion of this study offered opportunities for self-reporting bias. Information gathered was mostly supplemental to this study so it's unlikely to have much effect on the analysis.

Increasing participant uniformity would have been ideal, especially in consideration of motivation level and job activity level. Results show motivation level did not necessarily predict participants' metrics in this study. Still, now market proliferation has increased, future studies in this realm should strive for better uniformity than what this study was able to offer.

Another less than ideal circumstance was using the included Apple Watch applications for data collection and alerts. Unfortunately this meant it was not possible to completely separate Stand alerts from all other alerts, so participants got a goal completion alert when any of the main three metrics were completed for the day - Stand, Active Calories, or Exercise Minutes. Luckily these should only activate towards the end of the day and so should not offer much interference with the hourly Stand alerts, other than offering another potential reminder to pay attention to health goals.

The final potential issue was lack of uniformity of device wear from week to week. Increased reminders to participants to wear their device may have helped.

Conclusions

Unfortunately with such a small participant pool, this study was not able to prove Stand alerts decrease long stretches of sedentary time. On the other hand, all observed metrics showed suggestive positive change with the addition of alerts, to a such a degree it is likely a similar study with a few more participants would show a correlation.

Steps did show a significant increase with the use of Stand alerts, therefore we can conclude Stand alerts are more beneficial than having potential to decrease long stretches of sedentary time. If a wearer reacts to a Stand alert most hours, they will break up their sedentary time each hour and additionally increase other health metrics, especially Steps as found in this study.

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Appendix A: Participants' Demographic Data

Table A1 shows the demographical makeup of the participants in this study.

Table A1:

Participant Demographics

Total Participants		13
Gender	Male	7
	Female	6
Age	30-34	8
	35-39	3
	40-45	2
Owned and Wore Apple Watch	>3 months	2
	3-6 months	6
	6-12 months	6
Wear Time Each Day	8-12 hours	1
	>12 hours	1
	All waking hours	11
Use Alerts for Health Goals	Yes	10
	No	3
Workday Activity Level	Mostly Sitting	8

	Partly Active	3
	Mostly Active	2
Leisure Time Activity Level	Mostly Sitting	0
	Partly Active	9
	Mostly Active	4

Table A2, below, shows which metrics the study's 13 participants self-described as tracking the most, prior to joining this study.

Table A2:

Participant Demographics - Previously Tracked Metrics

Metrics Tracked	Number of Participants
Steps	9
Calories	8
Sedentary Time	8
Heart Rate	6
Distance on Foot	4
Workouts	3
Active Time	3
Sleep	2

Appendix B: Participant 1 - Raw Data

Table B1:

Participant 1 - Active Calories

Day	Week 1	Week 2	Week 3	Week 4
Monday	218	748	154	0
Tuesday	762	886	390	0
Wednesday	168	218	385	135
Thursday	278	119	20	250
Friday	278	711	0	937
Saturday	227	223	0	195
Sunday	144	219	0	197
Week Total	2,075	3,123	949	1,714

Table B2:

Participant 1 – Steps Taken

Day	Week 1	Week 2	Week 3	Week 4
Monday	6,661	10,867	2,866	2,218
Tuesday	9,300	9,091	7,182	3,220
Wednesday	2,079	3,251	6,942	2,350
Thursday	5,021	1,451	13,458	4,882
Friday	5,875	11,181	6,310	11,022
Saturday	3,070	4,681	4,319	4,900
Sunday	1,651	3,179	2,279	3,695
Week Total	33,656	43,701	43,356	32,287

Table B3:

Participant 1 – Stand Hours

Day	Week 1	Week 2	Week 3	Week 4
Monday	7	13	5	0
Tuesday	3	10	6	0
Wednesday	10	12	15	5
Thursday	10	8	0	8
Friday	9	13	0	12
Saturday	11	8	0	7
Sunday	9	8	0	10
Week Total	59	72	26	42

Table B4:

Participant 1 – Exercise Minutes

Day	Week 1	Week 2	Week 3	Week 4
Monday	9	85	7	0
Tuesday	99	108	38	0
Wednesday	5	8	10	4
Thursday	23	7	0	15
Friday	19	74	0	109
Saturday	8	12	0	8
Sunday	6	0	0	0
Week Total	169	294	55	136

Appendix C: Participant 2 - Raw Data

Table C1:

Participant 2 - Active Calories

Day	Week 1	Week 2	Week 3	Week 4
Monday	379	785	215	829
Tuesday	814	0	705	557
Wednesday	701	689	630	316
Thursday	726	355	403	319
Friday	767	709	263	358
Saturday	369	587	489	362
Sunday	354	206	242	667
Week Total	4,110	3,331	2,947	3,408

Table C2:

Participant 2 – Steps Taken

Day	Week 1	Week 2	Week 3	Week 4
Monday	8,235	8,225	3,911	11,841
Tuesday	7,888	7,218	8,466	10,565
Wednesday	8,503	7,350	8,305	6,392
Thursday	9,718	8,099	8,101	6,489
Friday	9,329	7,474	5,423	7,736
Saturday	7,406	3,076	13,476	7,137
Sunday	7,104	3,697	4,736	10,384
Week Total	58,183	45,139	52,418	60,544

Table C3:

Participant 2 – Stand Hours

Day	Week 1	Week 2	Week 3	Week 4
Monday	14	15	5	15
Tuesday	14	0	12	11
Wednesday	14	14	15	14
Thursday	17	16	15	16
Friday	17	15	15	18
Saturday	14	14	14	14
Sunday	11	12	12	14
Week Total	101	86	88	102

Table C4:

Participant 2 – Exercise Minutes

Day	Week 1	Week 2	Week 3	Week 4
Monday	41	93	14	92
Tuesday	93	0	15	51
Wednesday	81	91	73	21
Thursday	114	32	40	14
Friday	89	61	13	20
Saturday	26	49	27	29
Sunday	23	6	15	79
Week Total	467	332	197	306

Appendix D: Participant 3 - Raw Data

Table D1:

Participant 3 - Active Calories

Day	Week 1	Week 2	Week 3	Week 4
Monday	737	1,362	771	553
Tuesday	730	882	1,597	641
Wednesday	675	245	662	507
Thursday	542	431	630	494
Friday	649	818	1,958	1,685
Saturday	763	401	480	1,062
Sunday	314	0	517	524
Week Total	4,410	4,140	6,616	5,466

Table D2:

Participant 3 – Steps Taken

Day	Week 1	Week 2	Week 3	Week 4
Monday	10,512	11,982	10,904	7,371
Tuesday	9,946	10,467	10,892	10,383
Wednesday	8,687	4,040	9,338	6,066
Thursday	7,710	5,310	7,826	5,671
Friday	14,438	10,231	13,117	12,682
Saturday	12,255	7,391	6,403	13,256
Sunday	5,131	7,598	7,742	9,888
Week Total	68,680	57,019	66,223	65,316

Table D3:

Participant 3 – Stand Hours

Day	Week 1	Week 2	Week 3	Week 4
Monday	15	15	17	15
Tuesday	16	17	15	15
Wednesday	14	8	16	17
Thursday	14	15	17	17
Friday	15	12	16	17
Saturday	16	9	14	15
Sunday	13	0	16	15
Week Total	103	76	111	111

Table D4:

Participant 3 – Exercise Minutes

Day	Week 1	Week 2	Week 3	Week 4
Monday	37	81	63	32
Tuesday	49	47	143	44
Wednesday	51	9	32	16
Thursday	29	16	31	16
Friday	44	52	195	143
Saturday	45	12	15	107
Sunday	8	0	27	14
Week Total	263	217	506	372

Appendix E: Participant 4 - Raw Data

Table E1:

Participant 4 - Active Calories

Day	Week 1	Week 2	Week 3	Week 4
Monday	818	492	373	357
Tuesday	279	315	358	327
Wednesday	351	451	250	822
Thursday	320	751	658	344
Friday	264	207	294	419
Saturday	694	262	350	396
Sunday	247	369	455	420
Week Total	2,973	2,848	2,738	3,085

Table E2:

Participant 4 – Steps Taken

Day	Week 1	Week 2	Week 3	Week 4
Monday	11,982	10,445	8,112	7,280
Tuesday	6,005	7,139	7,515	6,557
Wednesday	6,929	8,050	7,002	13,069
Thursday	6,671	12,158	9,260	7,863
Friday	4,574	4,507	6,242	8,732
Saturday	11,498	6,720	8,380	9,897
Sunday	6,798	8,269	10,483	12,507
Week Total	54,458	57,288	56,995	65,904

Table E3:

Participant 4 – Stand Hours

Day	Week 1	Week 2	Week 3	Week 4
Monday	14	14	13	14
Tuesday	14	14	12	11
Wednesday	15	13	9	15
Thursday	14	11	11	13
Friday	16	9	11	11
Saturday	14	10	13	14
Sunday	14	11	13	9
Week Total	101	82	82	87

Table E4:

Participant 4 – Exercise Minutes

Day	Week 1	Week 2	Week 3	Week 4
Monday	113	52	54	42
Tuesday	41	34	46	36
Wednesday	45	62	35	126
Thursday	42	119	90	41
Friday	20	22	32	43
Saturday	89	30	37	32
Sunday	27	46	70	51
Week Total	377	365	364	371

Appendix F: Participant 6 - Raw Data

Note that Participant 5 failed to submit any data upon study completion.

Table F1:

Participant 6 - Active Calories

Day	Week 1	Week 2	Week 3	Week 4
Monday	475	511	147	398
Tuesday	713	439	535	371
Wednesday	481	580	179	468
Thursday	547	481	272	89
Friday	807	532	92	435
Saturday	220	180	4	395
Sunday	0	0	0	298
Week Total	3,244	2,722	1,228	2,454

Table F2:

Participant 6 – Steps Taken

Day	Week 1	Week 2	Week 3	Week 4
Monday	2,143	2,179	1,988	2,148
Tuesday	2,204	2,152	2,200	2,146
Wednesday	2,178	2,150	1,986	2,143
Thursday	2,199	2,099	2,067	1,943
Friday	2,170	2,148	1,947	2,173
Saturday	2,006	2,007	1,879	2,123
Sunday	1,875	1,875	1,875	2,113
Week Total	14,774	14,609	13,943	14,790

Table F3:

Participant 6 – Stand Hours

Day	Week 1	Week 2	Week 3	Week 4
Monday	13	14	6	13
Tuesday	17	13	13	13
Wednesday	17	14	6	13
Thursday	14	12	7	5
Friday	17	14	3	15
Saturday	7	7	0	13
Sunday	0	0	0	9
Week Total	85	74	35	81

Table F4:

Participant 6 – Exercise Minutes

Day	Week 1	Week 2	Week 3	Week 4
Monday	35	27	2	21
Tuesday	47	26	33	12
Wednesday	29	46	6	35
Thursday	33	37	12	3
Friday	74	41	1	14
Saturday	10	5	0	8
Sunday	0	0	0	3
Week Total	228	182	54	96

Appendix G: Participant 7 - Raw Data

Table G1:

Participant 7 - Active Calories

Day	Week 1	Week 2	Week 3	Week 4
Monday	514	334	786	442
Tuesday	555	564	624	292
Wednesday	726	311	319	863
Thursday	371	447	678	642
Friday	898	256	470	511
Saturday	736	207	1,285	262
Sunday	8	84	0	281
Week Total	3,808	2,203	4,162	3,292

Table G2:

Participant 7 – Steps Taken

Day	Week 1	Week 2	Week 3	Week 4
Monday	11,110	10,353	13,328	10,597
Tuesday	13,304	12,759	13,802	8,483
Wednesday	10,061	7,709	6,041	15,202
Thursday	9,280	12,172	15,117	17,629
Friday	20,285	10,887	11,717	11,838
Saturday	11,339	8,737	21,250	7,284
Sunday	4,335	1,470	765	4,931
Week Total	79,714	64,087	82,020	75,964

Table G3:

Participant 7 – Stand Hours

Day	Week 1	Week 2	Week 3	Week 4
Monday	12	13	13	14
Tuesday	15	13	17	8
Wednesday	7	8	12	14
Thursday	10	12	17	14
Friday	17	7	14	16
Saturday	13	6	15	10
Sunday	1	4	0	10
Week Total	75	63	88	86

Table G4:

Participant 7 – Exercise Minutes

Day	Week 1	Week 2	Week 3	Week 4
Monday	30	8	51	23
Tuesday	45	34	32	16
Wednesday	47	28	16	40
Thursday	16	23	49	52
Friday	73	10	26	24
Saturday	57	9	114	10
Sunday	0	4	0	7
Week Total	268	116	288	172

Appendix H: Participant 8 - Raw Data

Table H1:

Participant 8 - Active Calories

Day	Week 1	Week 2	Week 3	Week 4
Monday	234	271	307	423
Tuesday	250	305	315	252
Wednesday	277	150	315	270
Thursday	318	276	409	311
Friday	383	320	120	313
Saturday	152	319	228	283
Sunday	315	201	337	117
Week Total	1,927	1,842	2,032	1,968

Table H2:

Participant 8 – Steps Taken

Day	Week 1	Week 2	Week 3	Week 4
Monday	4,775	9,538	8,687	15,808
Tuesday	7,738	8,370	10,737	4,783
Wednesday	9,644	7,891	8,605	8,397
Thursday	9,013	8,226	12,915	8,169
Friday	10,573	9,422	6,321	8,621
Saturday	4,941	11,445	6,400	9,133
Sunday	10,119	5,297	13,400	6,501
Week Total	56,803	60,189	67,066	61,412

Table H3:

Participant 8 – Stand Hours

Day	Week 1	Week 2	Week 3	Week 4
Monday	10	13	13	7
Tuesday	12	14	14	9
Wednesday	13	5	16	14
Thursday	15	14	11	12
Friday	17	13	4	16
Saturday	5	9	8	12
Sunday	11	9	8	6
Week Total	83	77	74	76

Table H4:

Participant 8 – Exercise Minutes

Day	Week 1	Week 2	Week 3	Week 4
Monday	5	13	16	29
Tuesday	21	12	9	8
Wednesday	15	19	10	13
Thursday	22	19	20	20
Friday	34	21	3	19
Saturday	12	16	4	15
Sunday	38	11	20	4
Week Total	147	111	82	108

Appendix I: Participant 9 - Raw Data

Table I1:

Participant 9 - Active Calories

Day	Week 1	Week 2	Week 3	Week 4
Monday	541	566	482	424
Tuesday	437	560	443	424
Wednesday	523	503	550	503
Thursday	530	584	459	674
Friday	165	520	775	204
Saturday	100	370	237	728
Sunday	262	0	129	162
Week Total	2,557	3,103	3,076	3,118

Table I2:

Participant 9 – Steps Taken

Day	Week 1	Week 2	Week 3	Week 4
Monday	13,652	12,808	11,446	10,523
Tuesday	11,117	14,031	11,027	10,496
Wednesday	13,229	12,450	14,178	13,391
Thursday	10,878	13,111	10,259	16,899
Friday	5,306	11,343	20,686	16,330
Saturday	5,653	10,696	10,625	18,160
Sunday	6,879	3,745	4,641	5,589
Week Total	66,714	78,184	82,862	91,387

Table I3:

Participant 9 – Stand Hours

Day	Week 1	Week 2	Week 3	Week 4
Monday	15	14	15	15
Tuesday	16	15	15	14
Wednesday	13	15	15	17
Thursday	16	15	14	16
Friday	6	17	16	5
Saturday	5	12	12	16
Sunday	10	0	4	5
Week Total	81	88	91	88

Table I4:

Participant 9 – Exercise Minutes

Day	Week 1	Week 2	Week 3	Week 4
Monday	78	84	73	68
Tuesday	62	92	67	67
Wednesday	75	77	92	77
Thursday	68	102	70	108
Friday	9	80	146	39
Saturday	3	38	7	124
Sunday	21	0	22	29
Week Total	316	473	477	512

Appendix J: Participant 10 - Raw Data

Table J1:

Participant 10 - Active Calories

Day	Week 1	Week 2	Week 3	Week 4
Monday	491	397	629	734
Tuesday	485	617	722	412
Wednesday	468	604	579	491
Thursday	403	372	487	548
Friday	532	455	517	392
Saturday	643	675	703	717
Sunday	397	274	310	222
Week Total	3,419	3,395	3,947	3,515

Table J2:

Participant 10 – Steps Taken

Day	Week 1	Week 2	Week 3	Week 4
Monday	6,221	4,829	12,034	10,944
Tuesday	7,475	10,167	10,312	6,888
Wednesday	5,764	10,697	8,712	7,994
Thursday	5,320	3,093	7,673	8,233
Friday	9,117	8,178	9,326	5,988
Saturday	11,187	9,953	10,413	10,941
Sunday	19,783	2,599	5,382	7,104
Week Total	64,867	49,517	63,852	58,092

Table J3:

Participant 10 – Stand Hours

Day	Week 1	Week 2	Week 3	Week 4
Monday	16	13	16	16
Tuesday	14	9	15	14
Wednesday	15	17	12	15
Thursday	16	15	16	16
Friday	18	13	17	14
Saturday	10	16	12	14
Sunday	6	9	11	6
Week Total	95	92	99	95

Table J4:

Participant 10 – Exercise Minutes

Day	Week 1	Week 2	Week 3	Week 4
Monday	19	6	43	66
Tuesday	12	2	48	11
Wednesday	22	34	27	20
Thursday	12	2	19	22
Friday	19	40	13	14
Saturday	66	52	66	44
Sunday	29	2	14	5
Week Total	179	138	230	182

Appendix K: Participant 11 - Raw Data

Table K1:

Participant 11 - Active Calories

Day	Week 1	Week 2	Week 3	Week 4
Monday	283	282	208	216
Tuesday	282	265	222	216
Wednesday	301	263	210	182
Thursday	404	322	275	143
Friday	269	244	119	254
Saturday	173	329	68	187
Sunday	110	130	137	302
Week Total	1,821	1,835	1,238	1,500

Table K2:

Participant 11 – Steps Taken

Day	Week 1	Week 2	Week 3	Week 4
Monday	5,443	6,383	3,765	3,936
Tuesday	6,363	5,071	4,562	4,016
Wednesday	5,491	4,656	3,581	3,554
Thursday	9,817	6,576	6,354	2,659
Friday	7,694	6,231	1,165	4,180
Saturday	3,290	6,169	880	3,983
Sunday	1,026	2,223	2,385	6,997
Week Total	39,124	37,309	22,692	29,325

Table K3:

Participant 11 – Stand Hours

Day	Week 1	Week 2	Week 3	Week 4
Monday	13	14	13	9
Tuesday	12	13	11	15
Wednesday	13	14	10	10
Thursday	14	17	13	11
Friday	10	14	5	13
Saturday	8	10	2	8
Sunday	5	9	6	8
Week Total	75	91	60	74

Table K4:

Participant 11 – Exercise Minutes

Day	Week 1	Week 2	Week 3	Week 4
Monday	2	6	4	5
Tuesday	8	2	10	7
Wednesday	5	8	5	2
Thursday	23	7	14	1
Friday	14	5	0	4
Saturday	5	10	1	5
Sunday	1	1	2	22
Week Total	58	39	36	46

Appendix L: Participant 12 - Raw Data

Table L1:

Participant 12 - Active Calories

Day	Week 1	Week 2	Week 3	Week 4
Monday	209	285	391	385
Tuesday	240	310	402	397
Wednesday	284	197	331	328
Thursday	311	296	323	441
Friday	333	429	380	260
Saturday	276	265	170	110
Sunday	162	143	275	149
Week Total	1,816	1,925	2,272	2,070

Table L2:

Participant 12 – Steps Taken

Day	Week 1	Week 2	Week 3	Week 4
Monday	5,715	8,117	12,493	10,815
Tuesday	5,466	7,257	9,747	9,451
Wednesday	5,939	4,133	9,077	9,549
Thursday	9,075	7,168	8,908	8,017
Friday	8,377	7,400	8,608	7,817
Saturday	6,453	5,470	7,295	3,013
Sunday	3,753	4,262	6,164	3,382
Week Total	44,778	43,807	62,293	52,043

Table L3:

Participant 12 – Stand Hours

Day	Week 1	Week 2	Week 3	Week 4
Monday	12	13	14	14
Tuesday	17	14	14	16
Wednesday	16	13	14	16
Thursday	13	13	14	13
Friday	17	13	12	12
Saturday	14	14	5	6
Sunday	7	7	9	6
Week Total	96	87	82	83

Table L4:

Participant 12 – Exercise Minutes

Day	Week 1	Week 2	Week 3	Week 4
Monday	8	28	42	46
Tuesday	14	19	40	30
Wednesday	16	10	37	34
Thursday	23	21	32	48
Friday	17	56	24	19
Saturday	18	7	9	7
Sunday	10	5	21	5
Week Total	106	146	205	189

Appendix M: Participant 13 - Raw Data

Table M1:

Participant 13 - Active Calories

Day	Week 1	Week 2	Week 3	Week 4
Monday	193	138	183	74
Tuesday	457	421	961	345
Wednesday	555	1,068	447	484
Thursday	589	481	353	374
Friday	608	477	225	0
Saturday	1,258	913	622	1,122
Sunday	87	142	57	0
Week Total	3,747	3,639	2,848	2,399

Table M2:

Participant 13 – Steps Taken

Day	Week 1	Week 2	Week 3	Week 4
Monday	4,375	2,506	2,806	419
Tuesday	9,529	9,215	18,879	6,374
Wednesday	11,963	18,977	10,171	8,975
Thursday	12,124	9,981	5,392	7,528
Friday	13,789	9,460	5,911	9,102
Saturday	22,978	12,996	12,752	19,848
Sunday	1,776	1,875	1,989	288
Week Total	76,534	65,010	57,900	52,534

Note that Participant 13 failed to submit all requested data, and Participant 14, due to a technology error, failed to submit any data upon study completion.