The effectiveness of self-monitoring tools and texting prompts to increase physical activity in the workplace

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The effectiveness of self-monitoring tools and texting prompts to increase physical activity in the workplace

by

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A thesis submitted to the graduate faculty in partial fulfillment of the requirements for the degree of

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CHAPTER 1. INTRODUCTION

Worldwide, overweight and obesity have become epidemic issues as the WHO reports 1.5 billion people were overweight as of 2008, including 500 million obese adults (1). In the United States, the rate of overweight and obesity is currently 68.0% and continues to increase (2). These rates are especially worrisome considering the countless comorbidities associated with obesity. Adding to the problem, rates of physical inactivity, a major risk factor for the development of diseases including obesity, are currently very high. Recent studies indicate that less than 5-10% of adults in the United States actually meet recommended physical activity levels (3, 4). Additionally, data suggest that at least 25% of adult Americans are considered completely inactive (5).

Physical inactivity and lack of cardiorespiratory fitness increase the risk for cardiovascular disease, all-cause mortality, type two diabetes mellitus, hypertension, and various forms of cancer (5, 6, 7). In contrast, regular physical activity reduces the risk of colon cancer, type two diabetes mellitus, overall mortality, and may reduce the risk of developing depression (5). The Surgeon General has reported that even those individuals who are moderately active on a regular basis have lower mortality rates than the least active individuals (5). Discovering more effective ways to promote physical activity in society could significantly improve overall population health.

One contributing factor to this societal lack of physical activity is a reduction in work-related physical activity over the past half of a century. As technology has advanced, hard labor jobs have decreased causing the average job to become increasingly sedentary with occupational-related energy expenditure having declined by an estimated 100 calories per day (8). Interventions to increase physical activity in
workplaces offer considerable promise because they provide easy access to large captive audiences. This allows communication of health promotion efforts to be relatively simple and straightforward. Building upon the natural social support network that exists among employees in a worksite increases each participant’s chance of success at positively changing their behavior (9). Due to the increasing cost of employer-sponsored health care, an additional advantage of worksite programming is the direct financial incentive for companies to offer programming. The cost-benefit of worksite health promotion has been proven in many instances (10-14).

Studies have found that worksite health promotion programs are effective at positively impacting numerous health outcomes (13, 14, 15). However, the evidence regarding worksite health promotion efforts to increase fitness and physical activity among employees is mixed (15). Various physical activity interventions have been attempted at worksites, ranging from small poster campaigns (16) to larger, more intensive interventions such as in-person health coaching programs (17). Overall, inconsistent results from these studies raise questions about whether physical activity interventions within workplaces are effective. Because it is clear that worksite health promotion can indeed positively influence employee behavior, there is a need to find effective methods for increasing physical activity which can be implemented within pre-existing worksite health promotion program structures.

Self-monitoring technology, electronic prompting, and virtual health coaching are all potential solutions to improve the effectiveness of physical activity interventions within workplaces. New self-monitoring technology such as the Sensewear Pro Armband monitor (SWA) provide opportunities to help people learn to monitor and
improve their physical activity behavior. Several studies have demonstrated the potential of using the SWA as a self-monitoring tool (18-21). Utilizing the SWA in worksite programs may help people monitor their activity and weight control behaviors more effectively. The use of electronic prompts, particularly via text messaging and online health coaching, also offer promise for promoting behavior change in worksites (22-24). These reminders provide a cost-effective way to remind people to stay focused on their goals.

The primary purpose of this study was to determine the effectiveness on increasing physical activity of employees in a worksite setting of the combined use of a self-monitoring device (SWA) along with text messaging prompts and online health coaching compared to the effectiveness of the SWA independently. It is hypothesized that wearing a self-monitoring device (SWA) while also receiving text messaging prompts and online health coaching will be more effective at increasing physical activity than wearing the SWA alone.

References - Introduction


CHAPTER 2. REVIEW OF LITERATURE

Introduction

Among adults in the United States, the rate of overweight and obesity is currently 68.0% and continues to grow at a rapid rate (1). Worldwide, the WHO reports that as of 2008, 1.5 billion people worldwide were overweight including 500 million obese adults (2). Countless co-morbidities are associated with obesity including numerous debilitating diseases, and these in turn result in extremely high health care costs for obese individuals. Many factors have been linked to the development of obesity, a significant one of which is lack of physical activity.

Physical inactivity is known to be a major risk factor for the development of diseases including obesity, but also cardiovascular disease, type two diabetes mellitus, and hypertension (6, 7). Further, lack of cardiorespiratory fitness has been found to be an independent risk factor for cardiovascular and all-cause mortality (8). In contrast, there is a dose-response relationship between regular physical activity and decreased overall mortality. Regular physical activity reduces the risk of colon cancer, type two diabetes mellitus, and may reduce the risk of developing depression (6). Additionally, the Surgeon General has reported that even those individuals who are moderately active on a regular basis have lower mortality rates than the least active individuals (6).

The 2008 Physical Activity Guidelines for Americans recommends that adults engage in at least 150 minutes of moderate to vigorous physical activity each week. Data from the Behavioral Risk Factor Surveillance System (BRFSS) indicate that approximately 50 percent of Americans report accumulating this amount of physical activity each week (3). However, according to recent studies of NHANES data and objective measurements by accelerometry-based activity monitors, less than 5-10% of
adults in the United States actually meet this goal (4, 5). Data suggest that at least 25% of adult Americans are considered completely inactive (6). These reports indicate that most Americans are not meeting public health recommendations for physical activity. Significant changes in population health are possible if there were more effective ways to promote physical activity behavior in society.

A major contributor to the reduced level of physical activity is the sedentary nature of most jobs. Over the past 50 years there has been a dramatic reduction in work-related physical activity. As technological advances have allowed for less hard labor and more desk-based jobs, the average job has become increasingly sedentary. Daily occupational-related energy expenditure has decreased by an estimated 100 calories per day (9). To address this issue of physical inactivity, and also the broader, overwhelming issue of obesity, there is a need to find cost-effective interventions for increasing physical activity in society.

Interventions in workplaces offer considerable promise since they can target large numbers of sedentary workers. This literature review summarizes key issues with worksite health promotion programming and the specific types of intervention approaches that may prove to be most effective for promoting physical activity. These sections provide justification for the worksite physical activity study conducted.

**Worksite Health Promotion**

The increasing cost of employer-sponsored health care has sparked interest in worksite health promotion programming. Worksites are an ideal setting to promote healthful behaviors because they provide easy access to large captive audiences. This
allows communication of health promotion efforts to be relatively simple and straightforward. Additionally, putting such programs into place within a worksite builds upon a natural social support network that exists among employees in a worksite. This support network may increase each participant's chance of success at positively changing their behavior (10). An additional advantage of worksite programming is that there is a direct financial incentive for companies to offer programming.

The cost-benefit of worksite health promotion has been demonstrated in many studies (11-15). Emphasis in most programs is typically on trying to reduce health care costs; however, another way that companies benefit is by reducing absenteeism. Researchers have found that the costs of absenteeism, including the costs of lack of productivity due to chronic conditions, are actually greater in many cases than the direct medical costs from these conditions (16, 17). Evidence suggests that worksite health promotion can positively impact absenteeism by improving functionality and therefore productiveness of employees with chronic conditions or illnesses. Importantly, when implemented properly, physical activity interventions have been shown to decrease absenteeism (18). Thus, worksite health promotion can save companies money while also benefitting the health and well-being of employees (18).

Worksite health promotion can provide primary, secondary, as well as tertiary prevention programs to target employees who may have various needs (14). Programs which help employees increase physical activity can target all three levels of prevention, as physical activity can assist employees in maintaining good health (primary prevention), decrease the risk of certain conditions (secondary prevention), and can be part of the treatment for certain diseases or conditions (tertiary prevention). The
Department of Health and Human Services reports that the potential savings from chronic disease prevention are great and that the workplace is one important place to implement prevention programs (15).

Reviews of the literature have found worksite health promotion programs to be effective at positively impacting numerous health outcomes including improving blood pressure and cholesterol, reducing dietary fat intake, reducing cigarette use and risky alcohol-related behaviors, and increasing seat belt use (14, 15, 19). However, the evidence regarding worksite health promotion efforts to increase fitness and physical activity among employees is mixed. Literature in this area has shown small outcome effects and poor quality of studies in some instances (19). Some studies have shown slight improvements from the implementation of physical activity programs, while others have shown no significant effect. Additionally, many such studies have had few participants and have thus been underpowered.

Additional research is clearly needed to understand effective ways to promote physical activity in worksites. The structure of worksite health promotion has been shown to positively influence employee behaviors. However, a critical need is to find cost-effective methods for increasing physical activity which can be implemented within these pre-existing worksite health promotion program structures. A review of the approaches used in past physical activity interventions is provided below.

**Physical Activity Interventions**

Numerous physical activity interventions have been implemented and studied as part of worksite health promotion programming. These interventions have included
small campaigns within worksites focusing on increasing a single, positive physical activity behavior such as poster campaigns to encourage stair use instead of elevator use (20) or using treadmill workstations to increase steps taken throughout the day (21). Incorporation of small activity breaks into the normal daily work routine (22) and provision of worksite walking programs (23) have also been attempted. Though some such interventions have shown potential for success with small, short-term health benefits, such limited, simple interventions raise questions about the long-term potential for success, generalizability, and ability of such interventions to improve overall health status.

Larger physical activity interventions have included telephonic physical activity coaching programs (24) and internet-based interventions (25). These programs provide participants with tailored health coaching either over the phone or through a website which is tailored to each participant’s specific health needs. These sorts of interventions allow researchers to adapt components of the program to participants as their needs change, and also allows for more interaction, with participants able to have their specific questions answered by researchers. Such factors create more well-rounded interventions which would seem to provide an ideal environment to aid participants in improving their overall health status; however in order to provide telephonic coaching or tailored internet resources, increased numbers of personnel are required. With increased personnel comes increased financial burden, as well, which makes such studies less feasible for many worksites. Additionally, attrition has been an issue in telephonic coaching programs, while tailored internet programs have not been shown to be more effective for increasing physical activity than generalized internet programs.
Therefore, the time and financial burden of such studies, combined with mixed efficacy results, cast doubt on the effectiveness and feasibility of larger, tailored interventions to increase physical activity, as well.

Overall, the efficacy of these various interventions to increase physical activity has been mixed, with issues such as drop-out, small sample sizes, low participation rates, confounding factors such as simultaneous studies, and inconsistent results raising questions about whether physical activity interventions are effective and whether findings from these studies can be generalized to other populations (20, 22, 25). Components of two promising new intervention tools, self-monitoring technology and electronic prompts, are summarized below to highlight their potential for worksite programming.

*self-monitoring Technology:* The development of new self-monitoring devices provides promise for improving the effectiveness of worksite activity promotion programming. Pedometers have been used successfully for promoting physical activity but recently, lines of more highly powered self-monitoring devices have become available. An example is the Sensewear Pro Armband (SWA) monitor. The validity of the SWA for determining daily energy expenditure has been well established (26-28), and recent studies have also demonstrated its utility when used as part of a coordinated weight loss intervention (29-31). Wearable technology allows for real-time feedback about physical activity and other measures and provides positive feedback electronically to participants, which can enhance self-efficacy to change.

The SWA allows individuals to monitor their energy balance over time, with instant feedback available through a watch interface. Polzien et al (29) recently
demonstrated that individuals who used the SWA continuously throughout a 12-week intervention showed greater weight loss than those who wore the armband intermittently or who did not receive an armband. Shuger et al (31) as well as Pellegrini et al (30) have both shown that providing individuals with armbands in addition to a standard behavioral weight-loss program may enhance the effectiveness of the program and also increase adherence to a weight loss program that strives to increase physical activity. Increased adherence is a particularly crucial outcome from these studies, as attrition rates in physical activity interventions tend to be high.

Faculty, staff, and students at the Nutrition and Wellness Research Center at Iowa State University recently tested the utility of the SWA as part of a behaviorally based weight loss program (32, 33). Overweight adult participants were randomly assigned to one of three groups: a guided weight loss program with behavior skills training and health coaching (including motivational interviewing), a self-monitoring program using the SWA and weight management system (WMS) software, and a combined group which received both treatments. One thesis project conducted on this study examined the clinical outcomes associated with the different treatment programs (32). The investigators hypothesized that the group which received both treatments would show significantly greater weight loss. However, this study found no significant differences in weight loss between the three groups, suggesting that the SWA is as effective as a more intensive behaviorally based program. It may be clinically important to note, however, that the combined group did show greater (though not statistically significant) weight loss over the course of the study. Another thesis project conducted on this study evaluated the influences of the programming on self-management skills
thought to be important for sustained behavior change (33). This study showed that participants in the groups receiving health coaching improved their self-efficacy which may be important for the success of long-term weight management. Additionally, the findings from this study suggest that weekly meetings with a health coach and structured weight-loss program may increase behavioral processes of change which are thought to be necessary for success of weight loss efforts.

Initial evidence shows that health coaching for weight loss may elicit greater improvements in self-efficacy to change than would simply providing individuals with weight-loss technology, thus increasing participants’ chances of success in the long term. However, intensive counseling programs can be expensive and time-consuming, and the evidence currently does not support the need to incur these costs as evidenced by similar clinical outcomes among groups. However, one cost-effective solution to this issue is online health coaching, discussed below.

There is a need to study the effectiveness of the use of an armband-based intervention as part of a worksite health promotion program to target a large number of employees with minimal contact. As discussed previously, physical activity interventions in the worksite have shown mixed results, so determining whether providing an armband to individuals in a worksite health promotion program could increase the adherence to and efficacy of such programs would be a major step toward improving these programs and thus improving the health of employees. In order to improve chances of success in the long-term, a cost-effective solution that may be an option to use in place of costly counseling interventions is one of many new electronic prompting methods.
Electronic Prompts: The availability of various computers, cell phones, and social media technology has led to considerable interest in mediated behavior change interventions. This type of intervention can be delivered more cost-effectively than other individually-based education classes and may prove to be more effective over time. Research has shown that periodically prompting adults to perform healthy behaviors can increase their adherence to interventions, and therefore improve the health of these individuals (34). For instance, text-messaging reminders have been found to help individuals quit smoking, aid in weight-loss programs, and support the management of diabetes (35-37), while online health coaching has also been found to increase the likelihood of positive health behaviors (38, 39). The most effective timing for electronic prompts has been debated, with studies finding that more frequent (e.g. once per week) prompts tend to be more effective than less-frequent (e.g. once per month) prompts (38). It has also been found that these prompts do not need to be highly structured or specific to each participant, as less and more-highly structured prompts both improve participants’ adherence to healthy behaviors similarly (38).

Numerous forms of periodic prompting of subjects have been attempted, including email prompts, telephone calls, internet program prompts, and text message (SMS) reminders (34, 36, 37, 39). Text messaging is an especially convenient means by which to provide short prompts to subjects in order to encourage healthy behaviors (40, 41). As of 2010, more than 82% of American adults carried a cell phone (42). Of these, at least 73% used the text message feature at least occasionally, both numbers which continue to increase (43). Individuals typically carry their cellular telephones with them, or keep it close by, a majority of the time, so text messages are readily and
quickly received in a variety of settings. A prompt through email, an internet site, or phone call might not be received until the individual is able to check email or the internet site, or has time and is in the proper situation to be able to answer the phone or listen to a voicemail. Additionally, text message prompts are a cost-effective and time-efficient means by which to encourage behavior change and have overall been found to be effective in promoting positive behavior change (41, 44). Text message reminders were found to be more useful than email reminders in the management of blood glucose in diabetics (37). This was thought to be due to the fact that text messaging made it more feasible to contact subjects with an increased number of prompts as it was more convenient for subjects to receive these messages and for them to respond quickly to the prompts.

The ability of participants to quickly receive prompts is important in a worksite health promotion intervention designed to increase physical activity. One of the major reasons given for lack of physical activity is that individuals do not feel they have time to exercise. However, the American College of Sports Medicine and the American Heart Association emphasize in their joint guidelines regarding the amount of physical activity American adults should accumulate each day that this activity can be accumulated in bouts as short as ten minutes, spaced throughout the day (45). Additionally, studies have shown that incorporating short bouts of physical activity throughout the day, especially the work-day, can positively impact health and may be a more sustainable change than other physical activity interventions (46). Therefore, since text messages are more readily received than other prompting methods, employees reminded to be physically active in the form of a text message as part of a worksite health promotion
physical activity intervention may be more likely to incorporate short bouts of activity throughout their days.

In addition to text messaging, online health coaching can provide a communication channel through which individuals can receive prompts and relevant reminders from a health coach as they pursue a healthy lifestyle. As previously discussed, health coaching improves self-efficacy which may improve the likelihood of sustained behavior change (32, 33) but can be time-consuming and costly. New online tools such as the BodyMedia online ProConnect health coaching interface allow for a cost-effective way for individuals to gain similar feedback about their physical activity and nutrition behaviors.

Some combination of frequent, short text message reminders to be active along with specific feedback on physical activity behaviors from a health coach may inspire employees to begin, and maintain, regular physical activity patterns.

Conclusion

Most Americans do not incorporate enough physical activity into their daily lives and this has contributed to the high rates of obesity and countless other co-morbidities. One reason for the decline in physical activity participation over the past century is the increasingly sedentary nature of many jobs. Increasing physical activity in the lives of Americans could prevent many diseases while also improving well-being and functionality. The workplace is a convenient place to put into place interventions designed to increase physical activity. New self-monitoring technology such as the SWA provide opportunities to help people learn to monitor and change their physical activity
behavior. Combined with text message reminders and online health coaching, it may be possible to systematically promote increases in physical activity behavior. Such an intervention would be expected to be more sustainable than high cost in-person counseling or coaching programs. If successful, it offers a method which could be used in worksites to positively impact physical activity levels in employees. The proposed workplace intervention aims to provide a sustainable, effective workplace program to increase physical activity in office workers.

References – Review of Literature


CHAPTER 3. METHODS

Study Design and Recruitment

This study was designed as a randomized controlled trial to determine the effectiveness of self-monitoring tools, online health coaching, and texting prompts on increasing physical activity behaviors and improving exercise self-efficacy in sedentary employees. The study was conducted in partnership with a local company (National Center for Animal Health) in Ames, Iowa. Participants were recruited through email messages, flyers, and personal communication. Employees were excluded from participating if they were pregnant (or planned to become pregnant) or if they had medical risks that prevented them from being physically active. To be considered eligible for the study, participants needed to be between the ages of 20 and 65.

Eligibility to participate in the study was determined by having participants complete a pre-participation screening instrument. Participants provided demographic information as well as age and mobile phone ownership. They also completed the standard Physical Activity Readiness Questionnaire (PAR-Q) as a screening tool to determine their ability to safely participate in the physical activity intervention. Individuals that checked “yes” for one or more of the 7 items were required to obtain written permission from their physician in order to participate.

Participants that met the inclusion criteria were enrolled into the study and were randomly assigned into one of the two conditions: 1) Sense Wear Armband (SWA) and 2) SWA + reminders (SWA + R). Once subjects were enrolled, they had an initial data collection visit where height, weight, blood pressure, and bioelectric impedance body composition measurements were taken. At this time, participants completed the Global Physical Activity Questionnaire (GPAQ) to assess current activity habits. This tool
quantifies moderate and vigorous physical activity performed at work, while traveling, and during recreation, allowing for the estimation of total activity performed during a typical week (1). A 7-day physical activity recall was also recorded to quantify total energy expenditure and total time spent active in the past 7 days. Lastly, participants completed questionnaires to capture self-efficacy for exercise and perceptions of autonomy related to exercise behavior.

All participants provided written informed consent. All study procedures were approved by the Iowa State University Institutional Review Board.

**Procedures and Description of the Interventions**

The study was coordinated by trained health coaches supervised by a registered dietitian and other Ph.D. level researchers. The health coaches were graduate students who were instructed and supervised in appropriate health coaching communications and motivational strategies. Coaches were assigned to work with an equal number of participants in each of the two groups, providing a different level of support to each of the two groups as described in detail below. The health coaches did not communicate in-person with the participants, only via email or ProConnect software.

*Group 1: Sense Wear Armband (SWA):* Participants in this group were provided with a Sense Wear Armband, access to BodyMedia software, and a 1-page document describing the use of these instruments. The monitor was worn on the back of the non-dominant arm over the triceps. The BodyMedia dashboard allowed participants to view the energy they had expended throughout the day, as well as the amount of physical activity, sleep time and efficiency, and number of steps they took each day. Participants
could also view their caloric balance as part of the software, so they were encouraged (but not required) to enter their nutrition information into the BodyMedia software.

During the initial session, participants were encouraged to wear the armband as much as possible throughout the 8-week intervention, preferably downloading information about once every 3 days. To ensure the availability of data from all participants, two of the eight weeks were identified as required activity monitoring periods (Week 1 and Week 8). Participants in Group 1 (SWA) received brief check-in email communication from their health coach during weeks one, four, and prior to week eight. These emails served to encourage participants to follow the study through to completion. They did not include reminders to be physically active, but rather sought to encourage compliance with armband usage and ensure that participants understood how to use their armband.

**Group 2: SWA + Reminders (SWA + R):** This group received the same base treatment provided to Group 1 along with supplemental self-monitoring support and text message prompts. Unlike Group 1, this group had access to the "health coach" communications within the ProConnect software. This meant they could ask questions regarding use of the armband, their physical activity choices, nutrition, or any other component of the study. Participants in this group received feedback from their health coach once per week through ProConnect regarding their uploaded physical activity information. Coaches viewed data shown on each participant’s dashboard, and commented on the subjects’ positive efforts and behaviors to become more active. The coaches provided encouragement and offered suggestions as to how each subject could increase their physical activity throughout the day. Through these communications, the coaches assisted participants in determining ways to overcome
barriers they experienced in trying to be more physically active. Additionally, participants in this group received text message reminders at least twice per week which encouraged them through various messages to increase their physical activity behaviors. These text messages were short prompts with a new theme used for each week of the program. Examples of themes included ways to incorporate physical activity into the work day and reminders about the benefits of increasing physical activity. As with Group 1, participants in this group were asked to wear the armband as much as possible, but were specifically encouraged to wear it and download the information during weeks one and eight.

Data Collection

Anthropometric, physiological, physical activity, and exercise self-efficacy measures were collected at baseline and after week 8. During the final appointment, an additional survey to capture participant adherence to and satisfaction with the study was completed by participants.

*Anthropometric and Physiological Measures:* Height and weight measurements were taken without shoes and with lightweight clothing. Weight was measured using a balance beam scale and height using a slide stadiometer rod. Body Mass Index (BMI) was then calculated from these measures by dividing the weight in kilograms by the height in meters, squared. Percent body fat was measured using a handheld Omron bioelectric impedance analysis (BIA) tool. Blood pressure was measured in the seated position after participant had rested for 10 minutes using an electronic forearm cuff. The
measurement was taken twice and the average of the two measurements was recorded.

**Outcome Measures of Behavior Change**: The focus of the study was on promoting physical activity behavior and this was assessed with two different physical activity measures. The Global Physical Activity Questionnaire (GPAQ) was used to assess typical activity levels. This tool quantifies moderate and vigorous physical activity performed at work, while traveling, and during recreation, allowing for the estimation of total activity performed during a typical week (1). The GPAQ was scored by computing the MET-minutes associated with each type of activity category. The final outcome measure was computed as the total MET-minutes for the week.

The other physical activity measure was obtained from the Stanford 7-day Physical Activity Recall (7dPAR), a widely used and well validated measure of physical activity in adults (2, 3). The 7dPAR quantifies time in the last 7 days subjects spent sleeping, along with the amount of time spent performing moderate, hard, and very hard activities at work, during leisure time, and on the weekend. The 7dPAR was scored using standard procedures to compute the average daily energy expenditure as well as the time spent in moderate and vigorous physical activity. To facilitate comparisons with the GPAQ, the 7dPAR was scored to compute the total weekly MET-Minutes.

**Outcome Measures of Psychological Change**: Two common psychological measures were used to evaluate changes in self-monitoring capabilities. A measure of self-efficacy was selected to assess the participant's confidence in being physically active. This customized instrument was developed by Paulson et al (4) using guidelines set by Bandura (5). It evaluates participants' confidence that they could be physically
active in a number of adverse circumstances. The instrument included twelve questions scored using an 11-point Likert scale which ranged from zero (“not confident at all”) to ten (“very confident”). Participants were asked to answer whether they felt they could be physically active in situations such as vacation or during stressful times. The mean score on this scale was computed to reflect self-efficacy with higher scores indicating more confidence (See copy in the Appendix).

The other psychological measure was an indicator that reflects a participant’s relative degree of intrinsic and extrinsic motivation with regard to exercise. The widely accepted self-regulation questionnaire for exercise (SRQ-E) was used to capture this indicator. This 16-item instrument includes four component scales (external regulation, introjected regulation, identified regulation, and intrinsic motivation). These scales help identify the reasons underlying an individual’s behavior – in this case, exercise behaviors. Individuals who perform activities based on “control” (meaning a non-autonomous decision) score highly on external and introjected regulation, while those who score highly on identified and intrinsic regulation are considered to function autonomously and be more self-determined (6). Extrinsic motivation is considered the least internalized form of behavior, while intrinsic motivation indicates an individual has determined an activity is personally important and has integrated the importance of exercise behavior with other aspects of their self. A combined measure of autonomy (referred to as the Relative Autonomy Index (RAI)) was calculated as follows: RAI = 2*Intrinsic + Identified – Introjected – 2*External. A higher score indicates more internalized (autonomous) reasons for behavior, while a lower score – which may even
be negative – indicates more controlled, less autonomous reasons for behavior (See copy in the Appendix).

*Process Measures:* The intervention focused on the potential of the Sensewear monitor to facilitate awareness about physical activity behavior. Participants were provided with instructions about how to use and download information from the monitor. The participants in the health coaching option received additional prompts and coaching but both groups had access to the same armband technology during the study. The data from the Sensewear provides a measure of participant adherence to the study protocol and were used as process measures. The key process measure was the number of times each participant logged their armband data.

A secondary process measure was in the form of a survey provided at the second appointment. This survey captured participant adherence to study procedures as well as satisfaction with the study intervention tools including the SWA and dashboard, along with text message reminders and ProConnect software if applicable (SWA+R group) – See copy in the Appendix.

**Statistical Analysis**

Descriptive statistics (means and standard deviations) were computed for the two physical activity outcome measures and the two psychological outcome measures, as well as for the subscales of autonomy. The primary analyses focused on differences in outcomes between the two treatment conditions. Differences in group-level changes were then assessed with a series of three-way (Condition x Trial x Gender) ANOVAs.
Separate ANOVAs were run for the two physical activity outcome measures (GPAQ and PAR) and the two behavioral outcome measures (Autonomy and Self-Efficacy).

The main comparison of interest in each ANOVA analysis was the Condition by Trial interaction since it would test whether the effects on the outcome varied between the two conditions. However, two other comparisons were also examined. The Condition x Trial x Gender main effect would determine whether the effects were moderated by (or different between) genders. The Trial main effect is also of interest since this would reflect the overall effects associated with wearing the armband monitor. This is important since previous studies have demonstrated that the armband monitor on its own yielded similar outcomes as health coaching, and all participants in this study regardless of group were provided with an armband. We hypothesized that the combination of the armband with health coaching would help participants make more effective use of the self-monitoring features and assist in behavior change. Statistical significance for all tests was set at $p < 0.05$ and no adjustments were made for multiple comparisons since each outcome was viewed independently. SAS Software Version 9.2 was used to complete statistical analyses for this study.

References – Methods


CHAPTER 4. RESULTS

Descriptive Statistics

Sixty participants were randomized into one of two intervention groups, and 57 (14 males and 43 females) completed the 8-week intervention (90% remained in the SWA condition; 100% remained in the SWA + R condition). The breakdown of enrollment into the study is summarized in Figure 1.

Participants were recruited and guided through the intervention in a single cohort beginning in the fall. Descriptive characteristics of participants are provided in Table 1. The average age of participants was 44 years of age and ranged from 20 to 65 years. The males in this study had a mean BMI of 29.9 kg/m\(^2\) at baseline, and the mean BMI of women was 29.5 kg/m\(^2\), both values which would be classified as overweight according to standard definitions (25 kg/m\(^2\) < BMI < 30 kg/m\(^2\)).

Evaluation of Outcome Measures

The primary focus of this study was evaluating the possible impact of the SWA and SWA + R interventions on physical activity behavior. Preliminary screening of the data was conducted to check for possible outliers. Data were first plotted to check visually for possible outliers in the activity outcomes. The plots of GPAQ versus PAR revealed a number of points with disparate values (high scores on one estimate but low scores on others). While discrepancies can occur in data, the extreme disparities were attributed to confusion (or lack of effort) in completing the recall instruments. To objectively examine the outliers, the difference in the distribution of scores was then evaluated to determine if any values lay more than 2 SD units outside of the mean values for the distribution. These analyses revealed a number of potentially spurious
activity records. Most of the cases involved extremely high values on the PAR and almost no activity on the GPAQ (n =8), and some which indicated extremely high values on the GPAQ and significantly lower activity on the PAR (N=2). Since these two measures were assessing the same time period, these disparities may be attributed to inadequate understanding of one or both of the instruments (or poor compliance). Inclusion of these outliers could lead to spurious outcomes so the data from these 10 cases were removed (both the GPAQ and PAR). These cases included four males and six females, with five coming from each condition. One male and four females were removed from the SWA condition, and three males and two females were removed from the SWA+R condition. This resulted in slightly smaller sample sizes for the activity outcomes, leaving the data of ten males and 37 females for analysis. No outliers were detected in an evaluation of the behavioral outcomes. Changes in activity and biometric outcomes by trial are provided in Table 2, and changes in psychological outcomes by trial are provided in Table 3. Effect sizes from pre- to post- measures were also computed to reveal the magnitude of changes in each group. These were determined by computing the difference between pre and post measure means divided by the pooled standard deviation, and these values are included in Tables 2 and 3. Details of the statistical analyses of the changes in the outcomes are summarized below.

The F test for the 3-way ANOVA on GPAQ scores was not significant [F(7,103) = 1.89, p=0.08]. When individual effects were examined, there were non-significant effects for Condition x Trial (p=0.62) effect, the Condition x Trial x Gender interaction effect (p=0.39) and the Trial main effect (p=0.89). The plot of the overall Condition x Trial effect is shown in Figure 2.
The F test of the 3-way ANOVA for the PAR was significant \[F(7,104) = 4.93, p=0.001\]. There was a non-significant Condition x Trial effect (p=0.60) but the Condition x Trial x Gender interaction was significant (p=0.007). There was an increase in PAR scores in the treatment group compared to a decrease in PAR for the control group (see Figure 3) but this was obscured to some extent by the interaction with the gender term. The effect was more pronounced in males compared to females, as males in the SWA-R group increased their activity by an average of 636 MET-minutes from pre to post intervention, while females in the treatment group reported a slight decrease in MET-minutes from pre to post intervention (see Figure 4). The lack of an overall trial effect was caused by increases in males being cancelled out by decreases in females (p = 0.19).

Data from the GPAQ and PAR both suggest that participants reported being very active at baseline. On average, participants in both groups reported achieving well over the 500 MET minutes of moderate to vigorous physical activity recommended by the 2008 Physical Activity Guidelines throughout the course of the week.

The secondary outcomes of interest were the psychological changes that may underlie behavior change. The overall F-Test for the Self-Efficacy measure was significant \[F(7,113) = 2.06, p=0.05\]. There was a non-significant Condition x Trial effect (p=0.55), a non-significant Condition x Trial x Gender effect (p=0.17), but a significant Trial main effect (p=0.03) with values significantly lower on the post test. A plot showing the main Condition x Trial effect is shown in Figure 5 and it is apparent that the decline was evident in both conditions.
The F-test for the evaluation of the Autonomy outcome (RAI) was not significant \[F(7,13) = 0.65, p=0.72\]. The Condition x Trial interaction was not significant (p=0.92) and neither were the Condition x Trial x Gender effect (p=0.98) or the Trial main effect (p=0.47). Similar to self-efficacy, the RAI values were lower on the post test and this was consistent for both conditions (See Figure 6).

While there were few differences in outcomes between the groups it was important to analyze the factors that may have influenced behavior change. Correlations were examined between the psychosocial factors and the behavioral outcomes to determine whether self-efficacy and the autonomy index were related to physical activity behavior. These tests revealed low correlations among the measures. The correlations of GPAQ MET-minutes with Autonomy and Self-Efficacy were 0.04 and -0.10 respectively, while the correlations of PAR MET-minutes with Autonomy and Self-Efficacy were -0.04 and -0.08 respectively. This shows that these variables do not even seem to be significantly associated with the measured physical activity variables. The correlation between Autonomy and Self-Efficacy was 0.25, while the correlation between PAR and GPAQ MET-minutes was 0.35. Correlation coefficients for main outcomes separated by pre and post outcome are presented in Table 4.

**Evaluation of Process Measures**

The results of the main analyses revealed little overall effects for the groups but it is possible that the lack of effects were due to poor compliance with the protocol. This possibility was examined by looking at the process data obtained from the activity monitor and the post-survey. From the activity monitor, the number of times each
participant logged their data was obtained. Using these numbers, participants were stratified into one of three groups based on their logging frequency. Participants were encouraged to log their data at least once every 3 days, which equates to about 18 total times logging data. Three groups were created based on the degree of compliance with the recommendation: Group 1 (low compliance) included those who logged less than 8 times (about once per week or less; n=18); Group 2 (moderate compliance) included participants who logged 8-18 times (less than recommended; n=21); Group 3 (high compliance) included those who logged more than 18 times over the course of the 8-week study (n=28). Differences in study outcomes were compared across groups to determine if compliance moderated the effectiveness of the intervention. Plots were created to examine differences in the changes (post-pre) for each of the primary outcomes (PAR MET Minutes, GPAQ MET Minutes, Self-efficacy, and Autonomy). The results showed little or no difference when the results were stratified by degree of compliance (graphs not shown). The differences between groups were not significant for any variables but one interesting observation was that autonomy seemed to decline most in participants that downloaded the monitor the most (see figure 7). The effect sizes for all of the comparisons were small (ranging from 0.12 to 0.23).

Additional analyses were also completed to examine participant responses to the intervention. This data was obtained from a post-survey that summarized participants’ usage and acceptance of the armband, text messaging, and virtual health coaching. The frequencies of responses for each of the survey items are shown in Table 5. The results showed that overall, participants had a positive view of the armband and associated software, and made use of these tools nearly every day or on most days.
Results from the usage and satisfaction of online health coaching and text messages were more variable. Most subjects in the SWA+R group read the text messages, but very few stated that they took part in health coaching. In general, participants did not agree that online health coaching assisted in their behavior change efforts, and most agreed that rather than the ProConnect online health coaching they would have preferred in-person health coaching. Participants' views of whether the text messages assisted their behavior change efforts were mixed.
CHAPTER 5. DISCUSSION

The focus of this study was to evaluate the effectiveness of using the SenseWear armband monitor to promote physical activity behavior change when used within an existing worksite health promotion program. We hypothesized that the use of the armband monitor would help participants build behavioral skills that would help them be more physically active. We further theorized that participants would have more success with behavior change efforts if they were prompted through the use of periodic text messages and supported through online health coaching.

Worksite health promotion has been effective at assisting individuals to make healthy changes in many areas (1-3), but physical activity interventions within these corporate wellness programs have shown mixed results (4-6). In this study, we examined the possibility of providing a self-monitoring device to help participants change their behavior on their own. The BodyMedia armband has been successfully utilized as a tool in physical activity behavior change interventions. Shuger et al (7) and Pellegrini et al (8) have both shown that providing an armband to participants as part of a weight-loss program can increase effectiveness of, as well as adherence to, physical activity programs. Another recent study conducted at the Nutrition Wellness Research Center at Iowa State University (9) demonstrated that the SenseWear armband (SWA) was as effective as an intensive behaviorally-based program at encouraging behavior change and weight loss. Therefore, it was hypothesized that providing an armband alone could potentially encourage self-monitoring, and help employees increase physical activity behaviors even in the absence of other prompting or educational materials.
It was further hypothesized that providing reminders (or prompts) to be physically active through text messages and virtual health coaching would enhance the effectiveness of the armband intervention. Text messages are a cost-effective and simple way to prompt behavior change, and their effectiveness has been proven in several behavior change studies (10, 11). The benefit of providing information in this format is that a text message is readily received and thus can prompt physical activity bouts throughout the day. Since physical activity to improve health can be accumulated in bouts of as short as 10 minutes (12), these reminders were thought to be an ideal solution. It was predicted that text messages would not be sufficient on their own to cause behavior change, so participants in the treatment group also received virtual health coaching. Health coaching has been shown to enhance the effectiveness of physical activity behavior change interventions (9, 13), but can be costly and time-consuming. An advantage of the BodyMedia ProConnect software is that it makes the provision of electronic health coaching possible. This makes it potentially more cost-effective for use in worksite and community programs. The study was designed to evaluate whether the combination of health coaching and text messaging would enhance the effectiveness of the SenseWear monitoring device used alone.

The results of the study did not support the effectiveness of the monitor or the supplemental text/coaching treatment for changing physical activity behavior in a population which reported being active at baseline. There were non-significant main effects for Trial for each of the physical activity outcome measures. The results also did not reveal any significant Condition x Trial interactions suggesting that there were no differences in outcomes between the two conditions. Interestingly, a significant
Condition x Trial x Gender interaction was observed for the outcomes from the 7-day Physical Activity Recall in the SWA+R group. The results revealed a significant increase in physical activity for males from pre to post (p<0.05) but a decrease in the activity of females in this group. It is not clear why this was not evident for the GPAQ but it is possible that the GPAQ was not a sensitive enough instrument to capture difference between groups and changes over the course of this study. Overall, the PAR is a widely used and more robust tool than the GPAQ so the findings from this outcome are noteworthy. It may be that men responded more to the text messaging portion of the intervention, or that they felt more motivated than women to be active simply by self-monitoring with the use of the armband. Because men in this group showed an increase in physical activity while men in the SWA group did not, it is possible that text message reminders and/or health coaching were more effective for males than they were for females. Additionally, some participants commented on the post survey that they would have preferred text messages that were more tailored to their specific interests and needs. An area of potential future study, then, is to examine which types of reminders, prompts, or health coaching work more effectively for males and females, and tailor these messages to aid participants in reaching their specific personal goals.

The study also revealed little effects or changes in the psychosocial outcomes. Self-efficacy and autonomy for exercise were both examined as they have been shown to be mediating factors in behavior change (17, 18). These were tested to possibly help explain any changes in physical activity behavior in the study. While little is known about how to influence these mediators (19), it was hypothesized that the combination of self-monitoring technology, texting prompts, and virtual health coaching would prove
effective in improving these factors and thus positively influence physical activity behaviors. Each of these prompting/self-monitoring methods has previously been shown to be effective in increasing physical activity behavior (7-11, 13). Therefore, the design of this study was to combine these methods to increase physical activity and simultaneously study changes in self-efficacy and autonomy to determine whether these mediating factors were influenced by the intervention, as well. Similar to the results in the physical activity outcomes there was little movement or change in the psychological outcomes. A significant Trial main effect was noted for the Self-Efficacy outcome but this was in the opposite direction expected (i.e. with decreases evident from pre to post). The lack of significant effects makes sense considering the negligible changes in activity behavior but there were also fairly weak correlations between autonomy, self-efficacy, and physical activity behavior (see Table 4). Correlations between changes in the psychosocial variables and the physical activity variables were also low (data not shown). Therefore, the present study did not appear to support the importance of these psychosocial variables for physical activity behavior change.

One interesting observation was the fact that the largest effect sizes were found within the Self-Efficacy decreases from pre to post-intervention (see Table 3). One possible explanation for this decrease is increased awareness due to the armband monitor and dashboard. During the first appointment, participants may have felt they were generally able to be active in a number of adverse conditions, but viewing their armband data using the BodyMedia dashboard may have made participants more aware of their actual physical activity behaviors. If these showed lower values than participants’ perceptions of their physical activity behaviors, it may have adversely
affected their view of their personal ability to be physically active. Further study of this phenomenon and ways to bolster self-efficacy in interventions which involve offering participants an awareness tool such as an armband would be potentially beneficial.

The process data were examined to look at whether responses to the programming varied depending on the degree of self-monitoring. This was assessed by looking at the number of downloads. No major differences were detected based on the 3 logging groups: 1: less than once per week; 2: less than recommended; 3: equal to or more than recommended. The only interesting observation was that autonomy seemed to decline most in participants in group 3 that logged the most (See Figure 7). One explanation for the slightly greater decline in the group which had higher levels of self-monitoring is that they may have become increasingly extrinsically motivated as they grew to rely on the armband monitor and software rather than relying on their own abilities, but again the magnitude of these changes was small.

Stratification based on usage also revealed some interesting patterns in the post-survey data. On average, self-report values from the post-survey generally agreed with the usage data, with participants in group one indicating that they used the armband and logged their data least, while participants in group three reported the most usage and logging. Further, those in group three were most likely to report that the armband and software “definitely” reminded them to be active and helped them learn to monitor their data, while those in group one tended to indicate that the intervention “maybe” helped them learn to monitor their behavior and be active. Lastly, those in the highest usage category tended to report being more satisfied with the monitor and software than
those with the lowest usage values. These data indicate that commitment to logging data was important for participant perceptions of gaining useful skills from the monitor.

A number of possible reasons for the general lack of significant results exist. The first data collection visit occurred in early to mid-September. The second data collection visit occurred in mid-October. Several studies have found seasonal variations in the amount of physical activity performed by individuals, with higher amounts of activity in the spring and summer (April – September) and lower amounts of activity in the fall and winter (October – March) (14-16). Specifically in one study, leisure time energy expenditure was significantly lower during the winter and fall than during the spring and summer, and the Healthy People 2010 recommendation for moderate physical activity was only met during the spring and summer (16). Thus, it would be expected that physical activity would have declined over the course of this study. The fact that significant declines were not observed points to the possibility that this intervention may have had the effect of preserving physical activity patterns from the summer into the fall, where a decline would typically be expected.

Another issue in the current study that may have contributed to the results observed was a lack of adherence to study protocol on the part of the participants. Overall, there was a general non-response to the health coaches’ attempts to contact participants through ProConnect. Most participants only interacted with the health coach one to two times over the course of the study up to a maximum of 4 responses, while some never answered repeated contact attempts. Several drawbacks to the format of the ProConnect tool were observed throughout the course of the study which may have led to this lack of interaction. Accessibility to the ProConnect Software is not ideal.
Participants were able to connect their armband, sync their data or enter food intake, and log out of the dashboard without ever realizing they had a message from their health coach. Though participants did receive an email when they had a new message from their health coach, it seems this email may have been ignored or lost among participants’ many other emails. Additionally, the navigation to the ProConnect portion of the software was not intuitive. Many mouse clicks were required to access the ProConnect interface. It seems from the current study that participants are not likely to interact with a health coach through this interface on a regular basis (if at all). Due to the general lack of response, it is likely that the differences in the treatment groups were rather small and that the intended “intervention” of text messaging/health coaching was not implemented (or received) to the extent possible. Therefore, the groups could be considered to have received the same intervention with the exception of the text message prompts.

Other limitations of this study included a small sample size from a single worksite, which limits generalizability of the results. Additionally, behavior change can require a much longer time period than 8 weeks to occur (20-21), and even after such a lengthy intervention such changes may be difficult to maintain. So, the length of this study may have been of issue. Another limitation is the lack of physical activity measure other than physical activity surveys. A more objective measure such as data from the SWA may have provided different results as there is a tendency for overestimation of physical activity behaviors on surveys.

This study was designed to determine whether an intervention which involves self-monitoring technology with minimal contact and assistance from investigators would
be a lower cost, feasible way to deliver a worksite intervention to increase physical activity. The results indicate that some men who receive text messaging and health coaching prompts along with an armband may be likely to succeed in increasing their physical activity level, but more research is clearly needed. Further investigation of sex differences in factors which motivate physical activity would be pertinent to better understand this phenomenon. Future studies should seek a more user-friendly online health coaching system which would increase interaction between participants and coaches. This would allow for a thorough investigation of the impact of virtual health coaching on physical activity behavior. Increasing the length of similar studies in the future would also provide a better indicator of the intervention’s effectiveness.

New technologies including self-monitoring devices, texting reminders, and virtual health coaching provide promise for future physical activity (and other health-related) interventions that are low-cost and less time consuming than comprehensive in-person counseling. Further research is needed to determine the best ways to implement such tools to best support those who are trying to make positive changes in their health.

This study began to investigate possible implementation methods for these new tools. Findings from this study suggested that text messaging reminders in combination with a self-monitoring tool may be effective in assisting motivated males to increase their physical activity behaviors. These differing results between sexes point to the importance of tailoring interventions not only to different sexes, but also potentially to the personality characteristics, needs, and desires of each individual. Therefore, follow-up studies with designs similar to the study presented here but which take into account
participant preference and motivation will be helpful in determining the tools which will be of use to various individuals.

References – Results / Discussion


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Values for height, weight, and blood pressure are means ± standard deviation
SWA: SenseWear Armband Condition
SWA + R: SenseWear Armband + Reminders condition
Table 2. Behavior Change and Biometric Outcomes

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<th>SWA + R</th>
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<td><strong>GPAQ (MET-minutes/wk) (n=47)</strong></td>
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<tr>
<td>Pre</td>
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<td>1243.13 ± 981.10</td>
<td>1711.11 ± 1366.64</td>
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<td>1604.29 ± 1339.90</td>
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<tr>
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All values are means ± standard deviation
SWA: SenseWear Armband Condition
SWA + R: SenseWear Armband + Reminders condition
Table 3. Psychological Outcomes

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<td>Pre</td>
<td>6.52 ± 1.63</td>
<td>6.55 ± 1.67</td>
<td>6.48 ± 1.62</td>
</tr>
<tr>
<td>Post</td>
<td>5.53 ± 2.00</td>
<td>5.77 ± 2.00</td>
<td>5.31 ± 2.02</td>
</tr>
<tr>
<td>Change</td>
<td>-0.99 ± 1.47</td>
<td>-0.78 ± 1.66</td>
<td>-1.17 ± 1.28</td>
</tr>
<tr>
<td>Effect Size</td>
<td>0.543</td>
<td>0.423</td>
<td>0.639</td>
</tr>
<tr>
<td>Autonomy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>10.04 ± 3.76</td>
<td>10.50 ± 2.97</td>
<td>9.63 ± 4.36</td>
</tr>
<tr>
<td>Post</td>
<td>9.34 ± 3.45</td>
<td>9.74 ± 3.05</td>
<td>8.98 ± 3.79</td>
</tr>
<tr>
<td>Change</td>
<td>-0.70 ± 2.55</td>
<td>-0.76 ± 2.68</td>
<td>-0.65 ± 2.48</td>
</tr>
<tr>
<td>Effect Size</td>
<td>0.186</td>
<td>0.252</td>
<td>0.159</td>
</tr>
<tr>
<td>Extrinsic Motivation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>1.45 ± 0.84</td>
<td>1.31 ± 0.58</td>
<td>1.58 ± 1.01</td>
</tr>
<tr>
<td>Post</td>
<td>1.42 ± 0.78</td>
<td>1.36 ± 0.73</td>
<td>1.48 ± 0.82</td>
</tr>
<tr>
<td>Change</td>
<td>-0.03 ± 0.56</td>
<td>0.05 ± 0.40</td>
<td>-0.10 ± 0.66</td>
</tr>
<tr>
<td>Effect Size</td>
<td>0.037</td>
<td>-0.076</td>
<td>0.109</td>
</tr>
<tr>
<td>Introjected Motivation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>3.05 ± 1.23</td>
<td>2.80 ± 1.05</td>
<td>3.28 ± 1.36</td>
</tr>
<tr>
<td>Post</td>
<td>3.11 ± 1.31</td>
<td>2.88 ± 1.04</td>
<td>3.33 ± 1.50</td>
</tr>
<tr>
<td>Change</td>
<td>0.06 ± 0.92</td>
<td>0.08 ± 0.85</td>
<td>0.04 ± 1.00</td>
</tr>
<tr>
<td>Effect Size</td>
<td>-0.047</td>
<td>-0.077</td>
<td>-0.035</td>
</tr>
<tr>
<td>Identified Motivation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>5.93 ± 1.01</td>
<td>5.94 ± 1.03</td>
<td>5.93 ± 1.00</td>
</tr>
<tr>
<td>Post</td>
<td>5.75 ± 1.10</td>
<td>5.73 ± 0.89</td>
<td>5.77 ± 1.28</td>
</tr>
<tr>
<td>Change</td>
<td>-0.18 ± 0.68</td>
<td>-0.21 ± 0.76</td>
<td>-0.16 ± 0.61</td>
</tr>
<tr>
<td>Effect Size</td>
<td>0.17</td>
<td>0.218</td>
<td>0.139</td>
</tr>
<tr>
<td>Intrinsic Motivation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>5.03 ± 1.09</td>
<td>4.99 ± 0.93</td>
<td>5.07 ± 1.23</td>
</tr>
<tr>
<td>Post</td>
<td>4.77 ± 1.28</td>
<td>4.81 ± 1.11</td>
<td>4.74 ± 1.44</td>
</tr>
<tr>
<td>Change</td>
<td>-0.26 ± 0.90</td>
<td>-0.19 ± 0.96</td>
<td>-0.33 ± 0.86</td>
</tr>
<tr>
<td>Effect Size</td>
<td>0.219</td>
<td>0.176</td>
<td>0.246</td>
</tr>
</tbody>
</table>

All values are means ± standard deviation
SWA: SenseWear Armband Condition
SWA + R: SenseWear Armband + Reminders condition
Table 4. Correlation Coefficients for Main Outcomes (Pre/Post)

<table>
<thead>
<tr>
<th></th>
<th>GPAQ MET minutes</th>
<th>PAR MET minutes</th>
<th>Self-Efficacy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PAR MET minutes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>0.601</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post</td>
<td>0.493</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Self-Efficacy</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>0.436</td>
<td>0.103</td>
<td>0.103</td>
</tr>
<tr>
<td>Post</td>
<td>0.418</td>
<td>0.167</td>
<td>0.167</td>
</tr>
<tr>
<td><strong>Autonomy</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>0.259</td>
<td>0.058</td>
<td>0.329</td>
</tr>
<tr>
<td>Post</td>
<td>0.264</td>
<td>0.171</td>
<td>0.405</td>
</tr>
</tbody>
</table>
Table 5. Post-Process Survey Frequencies

<table>
<thead>
<tr>
<th>Reaction to Armband</th>
<th>Satisfaction/Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. How much did you use it?</td>
<td>37</td>
</tr>
<tr>
<td>b. Was the monitor comfortable to wear?</td>
<td>20</td>
</tr>
<tr>
<td>c. Did the monitor remind you to be active?</td>
<td>27</td>
</tr>
<tr>
<td>d. How satisfied were you with the monitor?</td>
<td>26</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reaction to Armband Software</th>
<th>Satisfaction/Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. How often did you log your data?</td>
<td>28</td>
</tr>
<tr>
<td>b. Was the software easy to use?</td>
<td>27</td>
</tr>
<tr>
<td>c. Did the software help you learn to monitor your behavior?</td>
<td>22</td>
</tr>
<tr>
<td>d. How satisfied were you with the BodyMedia Software?</td>
<td>23</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reaction to Coaching and Texting Prompts</th>
<th>Satisfaction/Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Did you take advantage of the health coaching (ProConnect)?</td>
<td>4</td>
</tr>
<tr>
<td>b. Did the health coaching help you to maintain &amp; support your efforts?</td>
<td>1</td>
</tr>
<tr>
<td>c. Would you have preferred to have in-person visits with a health coach</td>
<td>8</td>
</tr>
<tr>
<td>d. Did you read the posts provided in the text messages?</td>
<td>22</td>
</tr>
<tr>
<td>e. Did the text messages prompt you to be more active during the study?</td>
<td>2</td>
</tr>
</tbody>
</table>
Initial Screening (n=62)
Behavioral surveys, baseline biometric data collection

Excluded (n=2)
- Dropped out before randomization (n=1)
- High Blood Pressure (n=1)

Randomization (n=60)

SWA condition (n=30)

Drop Out (n=3)
- No response (n=2)
- Not ready (n=1)

Final data collection, Analysis (n=27)

SWA + R condition (n=30)

Final data collection, Analysis (n=30)

Figure 1. Participant Flow Chart
Figure 2. Mean change in GPAQ MET minutes (± SD) from pre to post-intervention between groups

Figure 3. Mean change in PAR MET minutes (± SD) from pre to post-intervention between groups
Figure 4. Mean change in PAR MET-minutes (± SD) from pre to post-intervention between groups and genders (M: male; F: female).

Figure 5. Mean change in self-efficacy score (± SD) from pre to post-intervention between groups.
Figure 6. Mean change in autonomy score (± SD) from pre to post-intervention between groups.

Figure 7. Mean change in autonomy score (± SD) from pre to post-intervention between usage tertiles (ES: Group 1=0.123, Group 2=0.189, Group 3=0.233)
7- Day Physical Activity Recall

Today is ___________________  Today's Date __________

1. Were you employed in the last seven days?  Yes  No (if no, please skip to question 4)
2. How many days of the last seven did you work?  ____ days
3. How many total hours did you work in the last seven days?  ____ hours last week
4. What two days do you consider your weekend days?  Please circle them below

WORKSHEET

<table>
<thead>
<tr>
<th></th>
<th>Sunday</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Saturday</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLEEP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MORNING</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hard</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very Hard</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AFTERNOON</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hard</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very Hard</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EVENING</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hard</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Very Hard</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Min Per Day</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strength:</td>
<td>____</td>
<td>____</td>
<td>____</td>
<td>____</td>
<td>____</td>
<td>____</td>
<td>____</td>
</tr>
<tr>
<td>Flexibility:</td>
<td>____</td>
<td>____</td>
<td>____</td>
<td>____</td>
<td>____</td>
<td>____</td>
<td>____</td>
</tr>
</tbody>
</table>

4a. Compared to your physical activity over the past three months, was last week's physical activity more, less or about the same?
   1. More
   2. Less
   3. About the same

Please draw an asterisk (*) next to any activities that were work-related
Global Physical Activity Questionnaire

This survey is meant to approximate the amount of time you spend doing different types of physical activity in a typical week. Please answer all questions even if you do not consider yourself to be a physically active person.

In each section, "vigorous-intensity activities" require hard physical effort and cause large increases in breathing or heart rate, while "moderate-intensity activities" require moderate physical effort and cause small increases in breathing or heart rate.

Activity at work: Consider paid and unpaid work, study, training, and household chores.

1. Does your work involve vigorous-intensity activity that causes large increases in breathing or heart rate (lifting heavy loads, construction work) for at least 10 minutes continuously? Yes No
   If NO, go to #4

2. In a typical week, on how many days do you do vigorous-intensity activities as part of your work? _____ days

3. How much time do you spend doing vigorous-intensity activities at work on a typical day? _____ minutes

4. Does your work involve moderate-intensity activity that causes small increases in breathing or heart rate (brisk walking, carrying light loads) for at least 10 minutes continuously? Yes No
   If NO, go to #7

5. In a typical week, on how many days do you do moderate-intensity activities as part of your work? _____ days

6. How much time do you spend doing moderate-intensity activities as part of your work? _____ minutes

Travel to and from places: Excluding the physical activities at work you have already mentioned, these questions are about the usual way you travel to and from work, shopping center, your place of worship, etc.

7. Do you walk or bicycle for at least 10 minutes to get to and from places? Yes No
   If NO, go to #10

8. In a typical week, on how many days do you walk or bicycle for at least 10 minutes continuously to get to and from places? _____ days

9. How much time do you spend walking or bicycling for travel on a typical day? _____ minutes

Recreational Activities: Excluding the work and transport activities you have already mentioned, these questions are about sports, fitness, and recreational activities you perform in your leisure time.

10. Do you do any vigorous-intensity sports, fitness, or recreational activities that cause large increases in breathing or heart rate (running, football) for at least 10 minutes continuously? Yes No
    If NO, go to #13

11. In a typical week, on how many days do you do vigorous-intensity sports, fitness, or recreational activities? _____ days

12. How much time do you spend doing vigorous-intensity sports, fitness, or recreational activity on a typical day? _____ minutes

13. Do you do any moderate-intensity sports, fitness, or recreational activities that cause a small increases in breathing or heart rate (brisk walking, swimming, cycling) for at least 10 minutes continuously? Yes No
    If NO, go to #16

14. In a typical week, on how many days do you do moderate-intensity sports, fitness, or recreational activities? _____ days

15. How much time do you spend doing moderate-intensity sports, fitness, or recreational activities on a typical day? _____ minutes

Sedentary Behavior: This question is about time spent sitting or reclining at work, at home, getting to and from places, or with friends (watching TV, at a desk, in a car, playing cards, reading, etc), but does not include time spent sleeping.

16. How much time do you usually spend sitting or reclining on a typical day? _____ minutes
APPENDIX B: PSYCHOLOGICAL SURVEYS

**Self-Efficacy for Physical Activity (SEA)**

How Confident Are You That You Can Be Physically Active?

*Please provide honest answers. The knowledge provided from your responses will increase the understanding and development of programs that are designed to help people manage life situations with which they have to cope.*

12 items are listed below that may influence your choice to *be physically active.* Please rate your confidence that you can be *physically active on a regular basis* using the scale:

0 = not confident to 10 = very confident

<table>
<thead>
<tr>
<th>How confident am I that I can be physically active</th>
<th>Please circle your response</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not confident</td>
</tr>
<tr>
<td>when I am anxious (nervous)</td>
<td>0 1 2 3 4 5 6 7 8 9 10</td>
</tr>
<tr>
<td>during the winter</td>
<td>0 1 2 3 4 5 6 7 8 9 10</td>
</tr>
<tr>
<td>when I am angry (or irritable)</td>
<td>0 1 2 3 4 5 6 7 8 9 10</td>
</tr>
<tr>
<td>during holiday seasons</td>
<td>0 1 2 3 4 5 6 7 8 9 10</td>
</tr>
<tr>
<td>when I experience family problems</td>
<td>0 1 2 3 4 5 6 7 8 9 10</td>
</tr>
<tr>
<td>when I am tired</td>
<td>0 1 2 3 4 5 6 7 8 9 10</td>
</tr>
<tr>
<td>when I am depressed (or down)</td>
<td>0 1 2 3 4 5 6 7 8 9 10</td>
</tr>
<tr>
<td>when I am exceptionally busy</td>
<td>0 1 2 3 4 5 6 7 8 9 10</td>
</tr>
<tr>
<td>when I am travelling or on vacation</td>
<td>0 1 2 3 4 5 6 7 8 9 10</td>
</tr>
<tr>
<td>when I am stressed</td>
<td>0 1 2 3 4 5 6 7 8 9 10</td>
</tr>
<tr>
<td>when visitors are present</td>
<td>0 1 2 3 4 5 6 7 8 9 10</td>
</tr>
<tr>
<td>when I am recovering from illness or injury</td>
<td>0 1 2 3 4 5 6 7 8 9 10</td>
</tr>
</tbody>
</table>
Motivation for Exercise

There are a variety of reasons why people exercise regularly. Please indicate how true each of these reasons is for why you exercise regularly. The scale is:

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>not at all true</td>
<td>somewhat true</td>
<td>very true</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

I try to exercise on a regular basis:

1. Because I would feel bad about myself if I did not.
2. Because others would be angry at me if I did not.
3. Because I enjoy exercising.
4. Because I would feel like a failure if I did not.
5. Because I feel like it's the best way to help myself.
6. Because people would think I'm a weak person if I did not.
7. Because I feel like I have no choice about exercising; others make me do it.
8. Because it is a challenge to accomplish my goal.
9. Because I believe exercise helps me feel better.
10. Because it's fun.
11. Because I worry that I would get in trouble with others if I did not.
12. Because it feels important to me personally to accomplish this goal.
13. Because I feel guilty if I do not exercise regularly.
14. Because I want others to acknowledge that I am doing what I have been told I should do.
15. Because it is interesting to see my own improvement.
16. Because feeling healthier is an important value for me.
APPENDIX C: POST-PROCESS SURVEY

Armband Monitoring Study – Participant Survey

1. Rate your overall use of and reaction to the Armband monitor

<table>
<thead>
<tr>
<th></th>
<th>Nearly every day</th>
<th>Most days</th>
<th>Some days</th>
<th>Not at all</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. How much did you use it?</td>
<td>Very comfortable</td>
<td>Somewhat comfortable</td>
<td>Somewhat uncomfortable</td>
<td>Very uncomfortable</td>
</tr>
<tr>
<td>b. Was the monitor comfortable to wear?</td>
<td>Definitely</td>
<td>Maybe</td>
<td>Not Likely</td>
<td>Definitely Not</td>
</tr>
<tr>
<td>c. Did the monitor remind you to be active?</td>
<td>Very Satisfied</td>
<td>Somewhat Satisfied</td>
<td>Somewhat unsatisfied</td>
<td>Very unsatisfied</td>
</tr>
<tr>
<td>d. How satisfied were you with the monitor?</td>
<td>Very Satisfied</td>
<td>Somewhat Satisfied</td>
<td>Somewhat unsatisfied</td>
<td>Very unsatisfied</td>
</tr>
</tbody>
</table>

Please tell us about your perceptions of the armband

What did you like about the armband?

What did you dislike about the armband?

2. Please tell us about your perceptions of the Bodymedia software (your “Dashboard”)

<table>
<thead>
<tr>
<th></th>
<th>Every few days</th>
<th>Most every week</th>
<th>A few times</th>
<th>Not at all</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. How often did you log your data?</td>
<td>Very easy</td>
<td>Somewhat easy</td>
<td>Somewhat difficult</td>
<td>Very difficult</td>
</tr>
<tr>
<td>b. Was the software easy to use?</td>
<td>Definitely</td>
<td>Maybe</td>
<td>Not Likely</td>
<td>Definitely Not</td>
</tr>
<tr>
<td>c. Did the software help you to learn to monitor your behavior?</td>
<td>Very Satisfied</td>
<td>Somewhat Satisfied</td>
<td>Somewhat unsatisfied</td>
<td>Very unsatisfied</td>
</tr>
</tbody>
</table>

Please provide some specific comments about the software

What did you like about the software interface?

What did you dislike (or would like to see changed) about the software interface?

Do you have any other comments about your experience with the monitor or the study?
3. Please tell us about your perceptions of the following health prompts

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>Sometimes</th>
<th>Rarely</th>
<th>Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Did you take advantage of the supplemental health coaching (Proconnect)?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Did the health coaching help you to maintain and support your efforts?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Would you have preferred to have in-person visits with a health coach?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Did you read the posts provided in the text messages?</td>
<td>Yes</td>
<td>Sometimes</td>
<td>Rarely</td>
<td>Never</td>
</tr>
<tr>
<td>e. Did the text messages prompt you to be more active during the study?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please provide some specific feedback about the Health Coaching

What did you like about the Pro Connect coaching?

What did you dislike (or would like to see changed) about the Pro Connect coaching?

Please provide some specific feedback about the Text messages

Did the text messages affect your behavior? In what ways?

If it were offered, would you like to continue receiving text messages about health topics?

*Participants in the SWA group only received page 1 of this survey; those in the SWA+R received both pages*