EXAMINING THE USE OF TAILORED HEALTH MESSAGES TO PROMOTE PHYSICAL ACTIVITY AMONG A NATIONAL SAMPLE OF INACTIVE BREAST CANCER SURVIVORS

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ABSTRACT

Leanne Kaye: Examining the Use of Tailored Health Messages to Promote Physical Activity among a National Sample of Inactive Breast Cancer Survivors
(Under the direction of Dianne S. Ward and Marci K. Campbell)

With continuous advancements in cancer care, the number of breast cancer survivors (BCS) living beyond five years continues to grow. While these advancements are encouraging, most survivors live with at least one side-effect of treatment, even six years after diagnosis. Engagement in regular physical activity (PA) can mitigate many of the physical and psychosocial side-effects experienced. As such, national PA guidelines recommend that BCS engage in regular PA. However, more than two-thirds of BCS fail to meet these guidelines. While some PA resources now exist for many of the challenges BCS face, these resources are often limited in reach and accessibility, and may be less effective due to the “one-size-fits-all” approach. Thus, this study aimed to develop and test the feasibility of a web-based, tailored intervention to promote PA among inactive BCS.

In aim 1, we conducted a validation study of a commercial accelerometer (Fitbit Zip) among 35 free-living, healthy adults. We found that the Fitbit was a valid tool for measuring step activity, but further interpretation of activity intensity (sedentary, light, moderate and vigorous activity) is needed. In aim 2, we evaluated the feasibility of a 12-week, web-based, tailored intervention to promote PA among 90 inactive breast cancer survivors. We demonstrated that a tailored web-based approach is acceptable and feasible to reach and recruit inactive BCS.
Furthermore, we demonstrated that weekly tailoring is an effective technique to promote moderate increases in walking steps (d=0.49 to 0.63), reduce sedentary time (p<0.05), and increase goal-setting behaviors (p<0.05) when compared to targeting. Finally, in aim 3, we evaluated the mediational role of the Self-determination Theory to promote PA. While we did not find any significant mediators, there appeared to be a moderating effect of autonomous and controlled motivation on step activity.

Our findings suggest that the Fitbit Zip is valid for measuring step activity, however, until more refined activity intensity algorithms are developed, it may serve best as a health promotion tool. Our study also suggests that an online, tailored, intervention is not only feasible to implement, but may also promote PA engagement and improve PA goal-achievement among inactive BCS.
In the middle of difficulty, lies opportunity—Albert Einstein
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LIST OF ABBREVIATIONS

ACS American Cancer Society
BMI – Body Mass Index
BCS – Breast Cancer Survivor
CA – Cancer
CDC Center for Disease Control and Surveillance
CPM – Counts per minute
GLTEQ—Godin Leisure Time Exercise Questionnaire
HEAL—Health, Eating, Activity & Lifestyle
IRB—Institutional Review Board
LOA—Limit of Agreement
MET Metabolic Equivalent
MVPA – Moderate to Vigorous activity
NHANES National Health and Nutrition Examination Survey
PA – Physical Activity
SCT—Social Cognitive Theory
SDT—Self-determination Theory
SMART—Specific, Measurable, Attainable, Realistic, Time specific
TSRQ—Treatment Self-regulation Questionnaire
CHAPTER I: INTRODUCTION

I.A. Overview

There are just under three million female breast cancer survivors living in the United States today, and this number is expected to grow to 3.7 million by the year 2022 (3). While these are encouraging trends in survival, the need to address long term side effects of treatment is becoming increasingly important. A recent study showed that more than 60% of breast cancer survivors live with at least one side-effect of treatment, even six years after diagnosis (1). Usual side-effects range from physical (weight gain, fatigue, weakness etc.) to psychosocial (mental health, emotional health, sexuality), and typically span the cancer care continuum.

Engagement in regular physical activity can mitigate many of the physical and psychosocial side effects of cancer treatment. As such, national physical activity guidelines recommend that breast cancer survivors engage at least 150 minutes of moderate-to-vigorous activity per week in addition to flexibility and strength training (2). However, more than two-thirds of breast cancer survivors fail to meet these guidelines following treatment (4, 5).

Self-directed, web-based interventions targeting inactivity hold promise in reaching more breast cancer survivors than traditional supervised interventions (6). However, self-directed programs often come in a ‘one-size-fits-all’ package which may miss the individual needs of a survivor. The use of a tailored messaging approach can help address a survivor’s unique needs (7), but also the incorporation of strategies like self-monitoring, problem-solving, and goal
setting may be successful in fostering behavior change through building autonomy and self-efficacy (8).

Few interventions to date, however, have utilized these approaches to increase physical activity among inactive breast cancer survivors. Furthermore, no interventions have utilized real-time, objective step data to tailor weekly step goals among breast cancer survivors post-treatment. As such, we aimed to develop a self-directed, tailored physical activity intervention that could be delivered using web- and technology-based tools. Thus, we propose the following dissertation aims:

**I.B Specific Aims**

**Phase 1: Fitbit Validation**

**AIM 1:** Validate the Fitbit Zip (a commercial accelerometer) in a sample of healthy, free-living adults over a 24-hour period by comparing and contrasting physical activity outcomes to a standard research accelerometer (ActiGraph GT3X).

**Phase 2: Randomized control trial to determine the feasibility of a web-based behavioral intervention to promote physical activity among a national sample of breast cancer survivors.**

**AIM 2:** Determine if a randomized 12-week, self-directed, *tailored* behavioral intervention will result in a significantly larger change in average daily steps (by week) from baseline to follow-up among inactive, post-treatment breast cancer survivors, when compared to a 12-week self-directed, *targeted*, behavioral intervention.
We hypothesized that participants randomized to the intervention group (tailored/targeted messaging) will engage in significantly more average daily steps between baseline and follow-up when compared to participants randomized to the comparison arm (targeted-only messaging).

AIM 3: Evaluate if changes in the hypothesized mediators (autonomy and self-efficacy) mediate the relationship between exposure to the intervention and change in physical activity (measured by average daily steps between baseline and midpoint, and self-reported physical activity between baseline and follow-up).
CHAPTER II: LITERATURE REVIEW

Inactivity as a Public Health Problem

Regular physical activity has been touted as one of the most important factors in achieving and maintaining good health. Current physical activity guidelines recommend that adults engage in at least 30 minutes of dedicated moderate to vigorous physical activity (MVPA) most days of the week—in addition to strength and flexibility training (9). This recommendation, in addition to habitual daily activity, equates to approximately 7,000-10,000 steps/day (10).

Engagement in regular activity has been shown to have multiple benefits which include improved physical functioning (stronger bones, muscle tone, weight control), reduced risk of chronic disease (cardiovascular, cancer, diabetes), and improved mental health status (mood, cognition) and quality of life (11). Furthermore, women who regularly meet physical activity guidelines have a 20-30% reduced risk of early morbidity and all-cause mortality compared to those women who do not (12, 13).

Despite the myriad of benefits, trends in physical activity leave much to be desired among adult women living in the United States. The Centers for Disease Control and Prevention (CDC) estimates that just 42% of women in the United States regularly report meeting physical activity guidelines (11). Objective data collected from the National Health and Nutrition Examination Survey (NHANES 2005-06) (14) paint a starker picture where it is estimated that more than 90% of women living in the U.S. are physically inactive. For the purposes of this
dissertation, physical inactivity is defined as those individuals who do not meet national physical activity guidelines, which is distinct from sedentary behavior which is defined as prolonged periods of reclining or sitting while awake (<1.5 METs) (15).

While physical inactivity is the fourth leading cause of non-communicable death among adults worldwide (16), women between the ages of 45-65 years report some of the lowest levels of inactivity, with just 1 in 5 meeting national activity recommendations. This trend is important to note because increasing age is an independent risk factor for developing chronic diseases like breast cancer (17).

Breast Cancer Survivors and Physical Activity

There are just under three million breast cancer survivors living in the United States today, and this number is expected to grow to 3.7 million by the year 2022 (3). While these increasing trends in survival are encouraging, post-treatment care is becoming more important as survivors live longer, and grow older with a number of post-treatment side effects. A recent study showed that more than 60% of breast cancer survivors live with at least one side-effect of treatment, even six years after diagnosis (1). Reported side-effects range from physical (weight gain, fatigue, weakness, lymphedema, etc.) to psychosocial and typically span the cancer care continuum (2).

However, studies have demonstrated that breast cancer survivors who regularly meet national physical activity guidelines for minutes of activity, have improved physical and psychosocial outcomes. A recent systematic review by Ballard-Bash (13) and colleagues suggested that physical activity was strongly associated with decreased all-cause mortality, as well as reduced breast- and colon cancer-specific mortality. Studies have also shown that regular physical activity in post-treatment breast cancer survivors is associated with improved
cardiorespiratory fitness (18), improved muscle strength and functionality (19, 20), improved quality of life and reduced anxiety (21), as well as reduced risk of secondary cancers (22).

Current physical activity guidelines released by The American Cancer Society (ACS) are similar to the national physical guidelines for healthy adults, but give the following specific recommendations for all cancer survivors: 1. Be active, 2. Avoid inactivity and return to normal daily activities as soon as possible after diagnosis, 3. Aim to exercise at least 150 minutes per week and, 4. Include strength training exercises at least two days per week (2).

Despite these targeted recommendations, less than one-third of cancer survivors engage in adequate physical activity (4, 23, 24). In a cross-sectional study of 451 cancer survivors, Midtgaard and colleagues reported significant decreases in self-reported physical activity between time of diagnosis and post-treatment status (25). Irwin and colleagues observed similar trends among breast cancer survivors, reporting that over two-thirds of breast cancer survivors remained inactive both during and after cancer treatment (26) regardless of stage of treatment, or stage of cancer.

Racial disparities in physical activity engagement also exist among breast cancer survivors. Between 1995 and 1999, 933 women with a history of breast cancer were enrolled into the Health, Eating, Activity and Lifestyle (HEAL) study (26). The findings showed that black breast cancer survivors were significantly less likely to engage in recommended levels of moderate to vigorous physical activity when compared to white and Hispanic breast cancer survivors (23% vs. 36%, respectively). African American women are of particular interest, and public health importance, as they have increased rates of mortality related to breast cancer, despite having lower incidence rates (27, 28). While prospective studies have suggested a reduced incidence rate of breast cancer diagnoses among African American women engaging in
recommended levels of MVPA (29, 30), physical activity trials for breast cancer survivors typically have poor racial diversity, and thus further investigations are needed to better understand these observations (28, 29).

**Barriers and Predictors of Physical Activity among Breast Cancer Survivors**

For many breast cancer survivors, treatment is not the last hurdle in their survivorship journey, but rather the beginning of many physical and psychosocial changes. Understandably, starting a physical activity routine often is not the priority, and even under the best intentions, breast cancer survivors face a number of hurdles in starting a physical activity regimen following the completion of treatment (31, 32).

A study by Irwin and colleagues (31) explored the specific barriers breast cancer survivors face in starting an exercise routine following treatment. The study revealed a number of key barriers hindering survivors from making physical activity a priority. These barriers may be best understood as two categories: environmental barriers and personal barriers. Typical environmental barriers observed included: inconsistent insurance coverage of physical activity programs for survivors, lack of clinical treatment plans that incorporate physical activity, inadequate facilities and/or counseling opportunities, and low priority given to promoting physical activity.

Personal barriers included the aforementioned physical side effects of treatment (fatigue, fear, bodily pain), as well as psychosocial changes (lack of behavioral/cognitive self-efficacy, self-motivation, reduced outcome expectancies, and lack of knowledge), as well as situational challenges related to inclement weather, lack of time, and/or caring for others.
Reaching Breast Cancer Survivors

While some resources (programs, information, support groups) now exist for many of the challenges breast cancer survivors face, it is clear that reach and access to environmental resources continue to be issues (31, 33). Web- and mobile-based technologies may offer a solution. In 2014, the PEW research counsel reported that more than 81% of adults living in the United States today have regular access to a laptop or desktop computer, and 87% of adults reported using the internet (34). Similar trends are observed for cell phone ownership and usage: 90% of US adults report using a cell phone, of which 58% report owning a smart phone. However, while younger adults (18-29 years) report higher rates of cellphone ownership than older adults (50-65 years) (98% vs. 88% respectively), as well as greater use of the internet (97% vs 88%), older adults still have relatively high ownership and usage rates. Interestingly, African American, as well as Hispanic adults in the U.S., are more likely to own a smartphone than white adults living in the U.S., but are less likely to be computer users (34, 35).

Thus it appears that web- and mobile- technologies present an opportunity to reach female breast cancer survivors. To understand how the internet is being used in research, we explored the behavioral intervention literature focusing on physical activity promotion. In a systematic review evaluating the use of internet-based randomized trials to promote physical activity, van den Berg and colleagues found that web-based interventions are as effective, if not more effective, than traditional non-web based trials (36). In a second systematic review, Vandelanotte and colleagues explored what mobile- and internet-based strategies were more effective in promoting physical activity among adults (37). While the review found no distinct associations between intervention elements and changes in physical activity, the number of intervention contacts, and overall study length appeared to be important (more than five contacts
had better outcomes; studies longer than three months had greater rates of attrition). As alluded to earlier, due to the large range in intervention methods, efficacy of behavioral modification strategies (e.g., goal-setting, assessment, feedback, reinforcement) could not be assessed, and future studies were strongly recommended to explore these findings further (these studies are addressed in the next chapter when we elaborate on the use of tailoring in behavioral interventions).

Behavioral interventions have also begun incorporating mobile-technologies and tools. While popular, it still remains important to utilize mobile-based instruments that have been tested for reliability and validity. This is especially important in behavioral interventions promoting physical activity. Traditionally, physical activity interventions have tracked and evaluated participant’s activity using self-reported questionnaires. While research demonstrates that these methods are effective in getting participants to report their activity in general terms, challenges remain in obtaining more detailed and consistent activity assessments, like the frequency, intensity, type and time spent in an activity, as well as the domains of activity (e.g., differences in leisure and occupational activity) (38).

Thus, the arrival of instrumentation to measure physical activity in an objective manner is a welcomed change. Objective measures do not rely on self-reported data, but rather track activity through various types of mechanical accelerometers and pedometers. Over the years, accelerometers and pedometers have become more efficient in collecting data on the aforementioned dimensions and domains of activity. While efficient, integration of these instruments is often limited, as accelerometers can be costly ($300-$400/ monitor), and pedometers are limited to step information only (38).
However, in recent years, due to greater demands for ‘quantified self’ health tools, lower cost, commercial accelerometer options have become available. One such commercial accelerometer is the Fitbit (Fitbit Inc., San Francisco, CA). The Fitbit is a small tri-axial accelerometer that tracks user activity in real time. The Fitbit uploads participant data via a Bluetooth connection, and data are synced with a personal website. There are four current models available (Zip, One, Force, Flex) and each varies in the type of activities recorded. At the very least, all models record step activity, minutes of activity in light, fair and very active intensities, distance traveled, sedentary time, and an estimation of calories burned. More advanced models allow for sleep monitoring, and have a built-in altimeters allowing users to track inclined physical activity. While commercial accelerometers, like the Fitbit, have filled an important gap in accessibility, validation and reliability studies are needed to evaluate how well such devices not only track activity, but how well the algorithms interpret intensity data collected from the accelerometer.
CHAPTER III: INTERVENTION FRAMEWORK

Tailoring Physical Activity Programs

While the development of web-based physical activity interventions may improve reach, effectiveness of such an intervention may be poor if a ‘one-size fits all’, or targeted, approach is used. Instead, a more customized, or tailored, approach to delivering a physical activity intervention may have additional benefit by meeting the individual needs of a participant.

A tailored approach in behavioral interventions may be best understood as the use of individual characteristics to develop health messages that are specific to a particular person. For example, tailoring may use an individual’s psychosocial parameters such as self-efficacy or motivation to exercise, to create a tailored message that addresses the unique needs of that individual (39, 40). In contrast, targeting of health messages may be best understood as developing messages based on shared characteristics of a group of individuals. For example, a group of breast cancer survivors may have a shared experience based on treatment type, diagnosis, or even barriers to activity, and so a targeted message around those generalized experiences could be developed (40).

A meta-analysis by Noar and colleagues demonstrated that tailored behavioral messages were more effective than non-tailored comparison messages, and significantly more effective than targeted comparison messages (39). The meta-analysis further indicated that tailoring was more effective when based on theoretical constructs, with greater success shown with use of
determinants from Bandura’s Social Cognitive Theory (41), as well as theories of motivation (e.g., Transtheoretical Model (42), Theory of Planned Behavior (43)).

These findings were mildly supported by a systematic review evaluating the role of tailored messages in interventions focusing solely on the promotion of physical activity (44). While the systematic review identified a number of tailored randomized trials, only one intervention specifically compared tailored messages to targeted messages (45). In this study, 280 sedentary women were randomized into one of three conditions: tailored, targeted, or a contact-control group. Intervention materials were based on theoretical determinants from the Stages of Change theory (46) and tailored specifically on processes of change for exercise, exercise self-efficacy, and decisional balance. The study ultimately suggested that participants randomized to the tailored group had slightly better physical activity outcomes when compared to the targeted group (p=0.054).

In a second meta-analysis evaluating the best intervention approaches to increase physical activity among chronically ill adults, findings indicated that interventions were more effective when they focused on just one behavioral outcome (e.g., diet or physical activity) versus multiple behavioral outcomes (e.g., diet+ physical activity (47)). Additionally, greater effects were observed when interventions included key behavioral strategies such as goal-setting or self-monitoring. This finding was echoed in a meta-analysis by Michie and colleagues (48) who demonstrated that self-monitoring was the single most important factor in behavior change interventions. Furthermore, Michie and colleagues reported that if self-monitoring was paired with just one other behavioral change technique (e.g., goal-setting), behavioral outcomes were significantly more effective (pooled effect size: 0.42 vs. 0.26).
Delivering Tailored Messages via the Internet

Finally, results from two meta-analyses evaluating the efficacy of delivering tailored messages via the internet (49, 50) suggest that web-based delivery of tailored messages were as effective as more traditional, non-web-based interventions. The meta-analyses further reiterated that goal-setting and self-monitoring, as well as theory-based messaging and message-based interaction with participants (e.g., text messages, emails), were effect strategies in promoting behavior change. This point was further illustrated in a meta-analysis of tailored health interventions where Lustria and colleagues (51) explored seven physical activity web-based tailored interventions. The analysis showed that increased feedback, and multiple or iterative assessments, enhanced intervention outcomes related to physical activity.

Physical Activity Determinants among Breast Cancer Survivors

Given these findings, the development of this thesis was framed on theoretical determinants drawn from two behavioral theories: the Self-Determination Theory (52, 53), and the Social Cognitive Theory (41). These theories were chosen because of their strong, positive associations with behavioral outcomes in both observational and experimental studies (54). In particular, research has demonstrated that self-efficacy, motivation, and self-regulation, have emerged as strong predictors of physical activity adoption and maintenance in inactive adults (54). Below, follows a deeper description of the aforementioned theories and their associated determinants.

Social Cognitive Theory

The Social Cognitive Theory (SCT) is a widely used learning-based theory explained by the dynamic interplay of personal (e.g., self-efficacy, outcome expectancies), behavioral (e.g., self-regulation/ goal-setting), and environmental (e.g., observational learning) attributes (41).
Behavioral change interventions have demonstrated that positive changes in personal and behavioral attributes are strongly associated with physical activity initiation and engagement (55-58).

Self-efficacy, a personal attribute, is defined as the confidence in one’s abilities to perform a particular task or behavior to achieve a specific outcome, such as engaging in physical activity to improve health. The SCT posits that higher, versus lower, self-efficacy leads to greater perceived behavioral mastery, thus leading to greater engagement of a specific behavior. On the other hand, self-regulation, a behavioral attribute, is best understood as a process of self-influence that may be subdivided into three main categories: self-monitoring of behavior, comparative assessment of behavior, and affective self-reaction. Self-monitoring is described as the self-assessment of one’s behaviors (e.g., tracking sedentary activity during the day), the determinants of the behavior (barriers, facilitators of the behavior), and the effects of the behavior (short- and long-term outcomes). Comparative assessment involves assessing one’s behavior in relations to one’s own standards as well as to one’s peers. This assessment encourages individuals to set goals for self-improvement or change. Finally, affective self-reaction refers to providing self-reinforcement of a behavior or self-punishment.

Thus, another core concept of SCT is goal-setting. The social cognitive theory posits that goal-setting is a critical component of self-regulation, which helps an individual monitor behavioral progress by either meeting or not meeting set goals. Bandura further posits that goals that set high expectations encourage greater effort than goals that set low expectations. While this makes intuitive sense, later studies found that large, lofty goals can be detrimental to behavioral progress and suggested that smaller, sequential, proximal goals with specific and reasonable challenges are more effective than larger, distal performance goals. For example, a
behavioral goal of exercising 150 minutes per week may be more effective if broken down into smaller, more achievable milestones, for example, exercising for 2-3 days a week for 20 minutes, then 4-5 days per week for 20 minutes+, and so on and so forth until the overall goal of 150 minutes per week is met.

**SCT Application to Physical Activity Behavior Change Interventions in Cancer Survivors**

The Social Cognitive Theory has guided a number of physical activity interventions and observational studies among cancer survivors (59). In a study by Pinto and colleagues, 86 breast cancer survivors (<5 years post-treatment, stage 0-II) were assessed for adherence to exercise following participation in 12-week home-based exercise intervention (60). The study was grounded in determinants drawn from the social cognitive theory and the trans-theoretical model. Specific SCT strategies included self-monitoring (using a pedometer provided), goal-setting (dependent of stage of motivational readiness), and problem-solving (barriers or challenges to reaching activity goals). The results of the study demonstrated that baseline self-efficacy was an important (and significant) predictor of exercise adherence as well as goal achievement. Specifically, the study demonstrated that for every unit increase in self-efficacy, participants took an additional 2637 (768) steps, and reported an additional 19.4 (5.5) minutes of weekly exercise. Pinto and colleagues also noted that participants who set SMART (specific, measurable, attainable, realistic, and timely) goals at the start of the intervention were more likely to be successful.

Similar results were found in a study by Rogers and colleagues who enrolled 41 breast cancer patients (61). Like Pinto’s study, Roger’s intervention was guided by the SCT, but also included guidance from physical activity correlates, and needs assessments with breast cancer
survivors. Specific SCT constructs included self-efficacy, reciprocal determinism, goal-setting, outcome expectations, behavioral capability, observational learning, self-control (regulation through goal-setting), and emotional coping. Not surprisingly, the study demonstrated, through a series of focus groups, that self-efficacy was one of the most important determinants for promoting physical activity engagement among breast cancer survivors. Other important determinants identified included outcome expectations and self-control.

Finally in a large behavioral intervention trial, Demark-Wahnefried and colleagues recruited 543 breast and prostate cancer survivors for a 10-month, sequentially tailored intervention aimed at improving both diet and physical activity outcomes (62). Participants randomized to the intervention received tailored booklets and newsletters, whereas the control group received a standard workbook prepared from the National Cancer Institute. Tailoring was based on stage of change, as well as SCT constructs to build behavioral skills and self-efficacy. Specific SCT strategies included positive reinforcement and setting of proximal goals. The study resulted in a significant change in minutes of physical activity between groups from baseline to follow-up (59 minutes vs. 39 minutes per week, p=0.02) as well as significant goal achievement (34% vs. 18%, p<0.0001). In the two-year follow-up study, findings in the total sample demonstrated that change in self-efficacy, as well as barriers to physical activity, was significantly correlated with total minutes of activity per week (63). While the results of the long-term follow-up are encouraging, authors cautioned that future studies should examine if such effects mediated outcomes, and if the observed effect would be maintained if delivered via web and mobile applications.
**Self-determination Theory**

The Self-Determination Theory (SDT) theorizes that the degree of one’s self-motivation (regulation) directly relates to one’s choice to engage in a behavior (e.g., starting an exercise program) (53, 64, 65). Motivation may be best understood as a sliding scale ranging from external motivation (controlled motivation), to intrinsic motivation (autonomous regulation) -- see Figure 1 below. Controlled motivations are best understood as those motivations that are socially or environmentally-based, and do not originate from the individual. For example, one might choose to engage in a new behavior in order achieve a reward or prize, or to avoid punishment or feelings of guilt. Controlled motivations are in stark contrast to autonomous motivations which originate from personal motivations. For example, one might choose to engage in a new behavior because of the inherent enjoyment or satisfaction gained from the behavior. The SDT posits that autonomous forms of motivation play a more significant role (compared to controlled forms of motivation) in promoting long-term behavioral engagement.
Figure 1: Self-Determination Scale of Motivation

SDT further theorizes that for behavioral interventions to move an individual away from controlled forms of motivation to more autonomous forms of motivation, the intervention must foster three key elements: autonomy, competence and relatedness (64, 66, 67).

**Autonomy:** Autonomy is defined as the perception of making independent or self-determined decisions—decisions that are not driven by external influences. For example, one may be more inclined to engage in physical activity if it is determined by the individual that engaging in such behavior was important for his/her health. The construct of autonomy may be enhanced through strategies that emphasize personal choice, provide rationale, and acknowledge barriers.

**Competence:** Competence is defined as the perception of being able to master a task or behavior. This concept is similar to self-efficacy in that the individual sets out to master a task—a key strategy used to develop self-efficacy in the Social Cognitive Theory. The construct of
competence may be enhanced through strategies like positive feedback, proximal goal-setting, and skill-building.

*Relatedness:* Finally, relatedness is defined as the ideal of wanting to share in other’s experiences. For example, a person scoring high in relatedness may benefit from an intervention that utilizes group-based settings. The construct of relatedness may be enhanced through behavioral strategies that incorporate group activities or promote feelings of connectedness to other participants.

**SDT Applications in Physical Activity Behavior Change Interventions**

As eluded to earlier, self-determination theory has demonstrated positive outcomes in both observational and experimental studies (68). One such behavioral trial explored if physical activity adoption was greater among overweight adult females with higher autonomy (69). Specifically, the study compared physical activity outcomes of a 12-month weight management intervention to a 12-month general health program. During bi-weekly group sessions, participants were encouraged to deepen their understanding of the importance of physical activity, make their own decisions and choices on types and frequency of activity, and explore any incongruences between self-declared values and activity goals. Ultimately, the study results showed a significant increase in autonomous regulation, as well as significant increases in step activity, and minutes of total activity, between study groups over time.

In a second 13-week behavioral intervention that aimed to increase physical activity, Fortier and colleagues enrolled 120 healthy adults in either a brief face-to-face standard counseling program, or an enhanced counseling program delivered via telephone/face-to-face counselors (70). Counseling was grounded in theoretical determinants of autonomy and
perceived competence. Strategies to enhance autonomous regulations included setting physical activity goals, problem-solving physical activity barriers, and soliciting social support. At follow-up, authors demonstrated that enhanced behavioral counseling was more effective in augmenting autonomous motivations and perceived competence than a standard brief counseling program for physical activity.

Finally, in a cross-sectional study by Peddle and colleagues (71), 414 colorectal-cancer survivors were asked to complete a mailed questionnaire evaluating autonomy, competence and relatedness in relation to physical activity. Using path analyses, the study showed that introjected and identified regulation were significant independent factors in predicting physical activity behavior, explaining 16% of the variation. Autonomy and relatedness were also significantly associated (independently) with introjected regulation (engaging in behavior to avoid feelings of guilt) and identified regulation (engaging in a behavior because of its personal value). Similar outcomes were noted in a cross-sectional study by Milne and colleagues (72). In this study, 558 breast cancer survivors were asked to complete a behavioral physical activity questionnaire. The study demonstrated again that both identified and introjected regulation were significant predictors of activity, as was intrinsic motivation. Furthermore, those participants who reported meeting physical activity guidelines reported significantly greater intrinsic motivation, and perceived competence.

The relationship between autonomy and behavior change appears to be an important one, but further research is needed to determine what role, if any, autonomous motivation plays in determining physical activity outcomes in online randomized trials. Further investigation is also needed to explore the role of introjected regulation. While introjected regulation is considered a more controlled form of motivation, studies have demonstrated its positive role in predicting
physical activity. While this observed relationship is potentially a result of study length (shorter studies bring quicker external reward), further research is needed.

Conceptual Model

Based on the aforementioned theories and highlighted behavioral determinants, we developed a conceptual model for promoting regular physical activity engagement among inactive breast cancer survivors. Specifically, our model draws on autonomy and perceived competence, as well as self-efficacy, self-monitoring, and proximal goal-setting. We hypothesized that these theoretical determinants would explain the relationship between motivation and self-efficacy and their effect on change in physical activity. For the purposes of our proposed study, we defined weekly physical activity as average steps taken as measured by the Fitbit Zip (see. Fig 2).

Figure 2 Conceptual Model of the Intervention
Summary and Implications

More than two-thirds of breast cancer survivors do not meet the national recommendation for physical activity (fewer than 150 minutes of moderate-to-vigorous activity/ week). Lack of regular activity is known to negatively impact both morbidity and mortality, and is especially pronounced among cancer survivors. Self-directed behavior change interventions may have improved outcomes for adopting moderate activity among post-treatment breast cancer survivors. One approach that has been successful in behavior change interventions is tailoring of messages. Tailoring is a customized approach where health messages are framed based on an individual’s characteristics (e.g., intrinsic motivation or self-efficacy), which is in contrast to targeting, where messages are based on shared group characteristics (e.g., race or age range). While both of these messaging approaches are useful intervention tools, tailored messages hold greater promise for individual behavior change than targeted messages, especially if grounded in behavioral theory, and thus may be an effective tool for increasing activity among breast cancer survivors.

This dissertation is grounded in the theories of self-determination and social cognitive learning, which both have successfully demonstrated facilitation of behavior change among adults in physical activity interventions. Specifically, research has suggested that the fostering of autonomous regulations, as well as self-efficacy, may have added benefits for maintaining new behaviors related to physical activity. These findings are of particular interest given the popularity of commercially-available activity monitors (e.g., the Fitbit) that engage users’ real time self-monitoring activity. Self-monitoring, in addition to strategies like goal-setting, have been shown to be successful strategies in behavior change.
Finally, a self-directed online program, such as the approach proposed, has the potential to address issues related to reach, accessibility (especially in rural or hard-to-reach populations), as well as sustainability. Moreover, the use of popular technologies, like the Fitbit Zip (Fitbit Inc., San Francisco), not only highlights the innovation of the study, but provides a practical and relatively inexpensive alternative to collecting repeated measures of objective activity data.

Ultimately, given the implications of such an intervention among breast cancer survivors, this dissertation was developed with community and dissemination in mind. Our intervention approach adopted a minimalist (versus “kitchen-sink”) approach, in hopes of minimizing costly resources, all while maintaining fundamental and necessary components to elicit positive behavioral change.
CHAPTER IV: VALIDATION OF THE FITBIT ZIP IN A SAMPLE OF FREE-LIVING, HEALTHY ADULTS

IV. A. Overview

The Fitbit Zip is a commercial accelerometer that provides objective feedback on daily physical activity (steps, intensity). The popularity of the Fitbit Zip has prompted interest regarding its validity to not only track daily activity in a free-living population, but also to classify activity intensity (sedentary, light, moderate and vigorous activity). Additionally, discussion ensues over the role of such new and more affordable technologies compared to traditional activity monitoring tools.

Thirty-five free-living, healthy, adults wore both a Fitbit Zip and ActiGraph GT3X for a 24-hour period. Participants also completed brief online pre/post activity questionnaires. Correlation coefficients, Limits of Agreement, and Bland-Altman plots were used to evaluate the Zip’s validity, as well as determine activity cut points. Non-wear time was estimated from the ActiGraph.

While the Fitbit Zip and ActiGraph were strongly correlated for average daily steps, the Fitbit Zip recorded about seven percent more steps than the ActiGraph. Smaller step differences were observed for step counts below 7,000 steps, and larger step differences were noted for step counts above 10,000 steps. Fitbit’s categorization of Lightly Active, Fairly Active, and Very Active activity most closely matched with the published cut points for light and moderate activity. Sedentary minutes were only strongly correlated once non-wear time was accounted for.
With some adjustment, the Fitbit Zip is a meaningful tool for measuring objective, real-time physical activity. The Zip recorded slightly more daily steps than the ActiGraph, but all outcomes were linear. The Zip appears to overestimate research-defined vigorous activity and thus intensity should be interpreted cautiously. Future research should identify an algorithm to calculate activity intensity, and distinguish between sedentary and non-wear time.
IV. B. Introduction:

The advancement of internet and mobile-based technologies for measuring physical activity has the potential to change current research practices. Such technologies are inviting for researchers as they are often less costly, user-friendly, and may provide real time feedback to both the user and researcher. However, despite strong interest in these new measurement tools, few of these technologies have been independently validated for use in a free-living adult population.

One such measurement tool is the Fitbit activity tracker (Fitbit Inc., San Francisco, CA). The Fitbit is a small, wearable accelerometer which enables the user to track his/her daily activity in real-time. There are various models available, and each varies in their utility and cost. All Fitbit models provide user feedback regarding steps taken, distance traveled, sedentary time, and activity intensity (Lightly Active, Fairly Active and Very Active). In addition, more advanced models (One, Flex, and Force) provide user feedback regarding activity incline (e.g., stairs climbed) and sleep data. Finally, Fitbit users have access to a private, no-cost website to track, review and plan their activity. The average cost (in 2014) of the Fitbit ranges from approximately $60 to $130.

At present, two peer-reviewed studies (73, 74) provide validity and reliability evidence for measuring physical activity using Fitbit activity monitors when tested in an exercise laboratory. In the first study, Noah and colleagues compared the validity and reliability of the Fitbit Tracker and Fitbit Ultra in a sample of 23 healthy adults. Physical activity outcomes (steps) were compared to industry-standard accelerometers (73). In the second study, Takacs and colleagues evaluated the Fitbit One in a sample of 30 healthy adults, and compared step and distance output respectively to video motion capture data and calibrated treadmill output (74).
Both of these studies showed that the Fitbit, regardless of the model, was valid and reliable for activity monitoring; specifically step counts and activity intensity. However, there was less agreement on distance output, and no evaluation of sedentary time. A third study by Visovsky and colleagues examined Fitbit accuracy in a free-living population over a 14-day period. While the study sample was limited (n=3), the authors demonstrated that there was still modest agreement for steps taken when comparing the Fitbit to the ActiGraph GT3X+ (75).

These aforementioned studies provided the initial evaluation for the Fitbit activity monitors, but more research is needed to evaluate validity evidence for the Fitbit in a larger sample of free-living healthy adults. (74) Because we were specifically interested in evaluating the Fitbit for steps taken, sedentary time, and activity intensity, we chose to evaluate the Fitbit Zip model. We also chose to compare the Fitbit Zip to a standard research accelerometer, the ActiGraph GT3X, which has good validity and reliability evidence for use among free-living healthy adults (76-78).

Thus, the purpose of this study was to produce validity evidence for the Fitbit Zip in a sample of healthy, free-living adults by comparing physical activity outcomes from the Fitbit Zip to commonly used outcomes from the ActiGraph GT3X (Freedson (79, 80), Troiano (78), and Matthew (81)). Because the method by which the Fitbit monitor classifies activity intensity has not been publically established, we also determined the ActiGraph cut points which most closely match the *Lightly Active, Fairly Active*, and *Very Active* estimates from the Fitbit Zip. In addition, comparisons between Fitbit Zip and ActiGraph outcomes and participant self-reported physical activity were evaluated.
IV. C. Methods

Participants and Setting

A sample of 35 healthy adults was recruited via email listservs and flyers posted at the University of North Carolina at Chapel Hill. Interested participants were encouraged to complete an online eligibility survey. Only those participants who were at least 18 years of age, able to ambulate without assistance, with a BMI score between 17-40 kg/m$^2$, and who were fluent in English met the eligibility criteria. Pregnant women in the 2$^{nd}$ or 3$^{rd}$ trimester were excluded. There were no sex or race restrictions.

Eligible participants were contacted via telephone by a member of the research team. During these calls, participants were provided with a more detailed description of the study and what they would be asked to do if they chose to enroll. If eligible participants remained interested in participating, they were then asked to provide verbal consent. Following consent, participants were scheduled for days/times to pick up and return the activity monitors. This study was approved by the University of North Carolina at Chapel Hill Institutional Review Board, IRB # 13-2432.

Data Collection & Pre- and Post- Questionnaires

Enrolled participants were asked to complete a brief online questionnaire before and after wearing the Fitbit Zip and ActiGraph. The baseline questionnaire included questions about general demographics, perceived health status, usual physical activity during the past week (self-reported minutes of moderate and/or vigorous activity) (82), screen time (television/ videos) and sedentary (sitting) behavior (14), and knowledge about current physical activity recommendations.
On the day of pickup, research assistants fitted each participant with an elastic belt such that both the ActiGraph and Fitbit Zip were snug to the right hip. Participants were provided with a care instruction sheet and instructed to wear the activity monitors the following day for all waking hours (with the exception of water-based activities, ex. bathing and swimming).

The day after the activity monitors were worn, participants returned the equipment and completed the online follow-up questionnaire. The questionnaire included questions about physical activity for the previous day (modified IPAQ questions for self-reported minutes of moderate and/or vigorous activity) (82), as well as screen time and sedentary behavior (14), beliefs and attitudes towards exercise (52) and feedback on wearing the monitors.

Device Description

The Fitbit Zip (Fitbit Inc., San Francisco, CA) is a small tri-axial accelerometer that provides real-time activity feedback on steps taken, distance traveled, and active minutes. Activity data can be wirelessly uploaded to a personal user profile on the Fitbit website, where users can see a daily breakdown of Light, Fairly Active, and Very Active minutes, total steps, and an overall Activity Score. In addition, a daily summary graph showing the number of steps taken in 15 minute increments is provided. Classification of Fitbit activity intensity is defined by Fitbit, but is not publically available.

For this study, daily activity estimates were extracted from the website using a computer program. The 15-minute step data were not available in the information automatically collected and were therefore recorded by research staff directly from the Fitbit website. For this manually recorded data, 25% of participants were selected for double entry to monitor error rates. In total, 684 (25.7%) of the 15-minute observations were checked. Of these, six were found to be
different (error rate = 0.88%). On average, these observations differed by about nine steps per 15-minute block. For all 684 observations, average steps per 15-minute block differed by 0.07 steps between the first and second entry and the correlation was \( r = 0.999 \).

The ActiGraph GT3X is a tri-axial accelerometer that is used extensively in physical activity based research. Evidence of validity and reliability for this monitor is strong in both laboratory and free-living conditions (76, 78). While the monitor does not provide real time feedback to the user, it does collect and store time stamped acceleration data allowing for more detailed information about user activity to be obtained. Acceleration data from the ActiGraph GT3X were summarized into counts per 10 second epoch and non-wear time was estimated using the NHANES algorithm (78). Using these methods, each epoch was classified into an intensity category based on research defined cut points (e.g., above 6000 counts = Vigorous Activity).

For comparison to Fitbit data, ActiGraph steps were obtained, and minutes in several intensity categories were estimated using common cut points as defined by Crouter (83, 84), Freedson (79, 80), Matthew (81), and NHANES (78) (see Table 4.2 in the Appendix, which outline the aforementioned cut points). In order to determine the ActiGraph cut points, or count levels, which best matched with Fitbit activity estimates, a dataset was created which contained minutes above each count level from 0cpm to 8000cpm in 50 count increments (e.g. \( \text{Var}0 = \text{mins} > 0 \text{cnts} \), \( \text{Var}50 = \text{mins} > 50 \text{cnts} \), \( \text{Var}100 = \text{mins} > 100\text{cnts} \), etc.). Data processing was conducted using SAS v9.1.
Analysis

Primary analyses were conducted using Fitbit and ActiGraph activity data summarized both at the day level and the 15-minute block level. Day-level data analysis included total daily steps and minutes per day in various activity intensities. Block level analysis included estimated steps for each 15-minute block. For the analysis of the 15-minute level data, only blocks with at least 11 minutes of wear time (80% wear) recorded between 5am and 11:59pm were included. Wear time per block was estimated during the ActiGraph processing.

Activity estimates were compared using signed and absolute deviations, limits of agreement, correlation, coefficient of variation, deviations as percent of mean, kappa, and percent agreement. Scatter and Bland-Altman plots were created for each comparison (not all shown). Basic descriptive analyses were conducted and presented for all variables examined, including self-reported demographics.

In order to determine the ActiGraph cut points which most closely replicated Fitbit estimates of Sedentary, Lightly Active, Fairly Active, and Very Active minutes, a SAS algorithm was created. The algorithm was used to compute the correlation, signed and absolute deviations, and coefficient of variation between the Fitbit and ActiGraph outcomes. The code compared a selected Fitbit variable to each of the 160 ActiGraph outcomes. Each of the ActiGraph outcomes was minutes above a cut-point from 0cpm to 8000cpm in 50 count increments. The algorithm was designed to save and plot comparison statistics for all 160 comparisons and identify the best three cut points. The top three cut points were selected based on the highest correlations and smallest deviations at the group and individual levels.

Before applying the SAS code to the Fitbit variables it was tested on three outcomes associated with known ActiGraph cut points. In each case, the code precisely identified the
count level used to compute the variable. For example, using minutes in vigorous activity computed with the NHANES cut points (78), the algorithm identified the cut-point as 6000cpm. The actual cut is 5999cpm. Three Fitbit variables were processed using this SAS code, allowing the identification of the separation point for the four Fitbit intensity levels in ActiGraph measurement “units”, or counts. Fitbit Lightly Active + Fairly Active + Very Active was used to identify the cut between sedentary and light. Fitbit Fairly Active + Very Active was used to identify the cut between Lightly Active and Fairly Active. Fitbit Very Active was used to identify the cut between Fairly Active and Very Active.

Finally, to further validate findings, self-reported minutes of activity (moderate and/or vigorous minutes, screen time, and sitting time) was compared and contrasted using correlations which identified the strength and direction of relationships between self-reported minutes of activity, and data collected by the Fitbit and ActiGraph. Self-reported minutes of moderate and vigorous activity, as well as screen time activity, were categorical variables. Self-reported sitting time was a continuous variable.

IV. D. Results

Participants were primarily white (74%), female (66%), and well-educated. The average age of participants was 31.8 (9.16) years, with an average reported BMI of 24.5 (5.43) kg/m$^2$ (see Supplemental Table 4.1 in Appendix, which outlines participant demographics). Activity output was compared between the Fitbit and the ActiGraph (Table 1). The Fitbit recorded an average of 9286 (4134) daily steps and 915.2 minutes of total activity (adjusted for Sedentary time). In comparison, the ActiGraph recorded an average of 8591 (3883) steps and 913.3 minutes of total activity during the 24-hour study period.
A total of 2099 15-minute blocks were included in the final analysis. The Fitbit recorded a mean of 152 (313) steps per 15-minute block, whereas the ActiGraph recorded 142(280) steps per 15-minute block. Six outlying observations were identified in the 15-minute block data. While the outlier values were high, they were not impossible and did not appear to result from monitor error. Analyses with and without these observations were nearly identical, therefore the observations were retained.

**Comparing Total Steps and 15- minute Block Steps**

On average, the Fitbit Zip recorded approximately seven percent (~676 steps) more steps than the ActiGraph. This difference varied slightly for days with less than 7000 Fitbit steps (n=12; 4.6% difference) compared to days with more than 10,000 Fitbit steps (n = 13; 8.6% difference). While the differences between these step levels were statistically significant (p = 0.044), both estimates and the difference are still considered small. Furthermore, there was a very strong correlation between the Fitbit and ActiGraph accelerometers (r=0.98), suggesting that the difference in step estimation is consistent. Additionally, Bland-Altman plots affirmed low levels of discrepancy with a 95% Limit of Agreement (LOA) of +/- 1625 steps per day, and 75% LOA at +/- 953 steps per day (Fig. 4.1).

Results also showed that the Fitbit and ActiGraph 15-minute block step estimates were very strongly correlated (r= 0.985). Regression analyses and Bland-Altman plots again indicated strong agreement for the 15-minute step blocks, with an average deviation of ~10 steps per 15 minute block (Fig. 4.2).

To see if the difference between steps estimated by the Fitbit and ActiGraph varied by the number of steps taken during a 15-minute block, we examined deviations between the two step
estimates in 10 steps per block categories. Observations were categorized based on the Fitbit step estimate for a given block. Grouping categories and deviations for this comparison can be found in Figure 3. While the coefficient of variation remained fairly consistent across categories, it is important to note that the average step counts for the ActiGraph were higher than the Fitbit below 100 steps per 15-minute block. However, this trend is reversed for steps per block above 100, such that the Fitbit recorded more steps than the ActiGraph.

Comparing Classification of Activity Intensity

Table 4.1 also compares Sedentary, Lightly Active, Fairly Active, and Very Active Fitbit minutes to minutes of activity recorded by the ActiGraph. On average, the Fitbit Zip reported approximately 540 more minutes of Sedentary time compared to the ActiGraph. However, after the Fitbit Zip Sedentary minutes were adjusted (Fitbit Zip Sedentary minutes minus ActiGraph non-wear minutes), sedentary minutes of activity became strongly correlated between the two monitors (r=0.96). Further confirmation for use of the Adjusted Sedentary minutes was observed with Bland-Altman plots which also demonstrated strong levels of agreement between the accelerometers (figure not shown).

In Table 4.1, it was also observed that Lightly Active minutes was strongly correlated with NHANES cut points for light activity (r=0.71), but actual differences were 67.6 minutes (deviation % about mean=98.1%). Fairly Active minutes, as recorded by the Fitbit Zip, was poorly correlated with the NHANES moderate cut point (r=0.26). However, a stronger correlation was observed between Fairly Active minutes and Matthews’ lifestyle cut point of 760cpm (r=0.50, deviation= -33.6mins, deviation % of mean =46.9%). Very Active minutes was moderately correlated with the NHANES vigorous cut point (r=0.54), but had a strong
correlation with the NHANES MVPA cut point ($r=.89$, deviation=-17.7mins, deviation % about mean= 41.1%). Finally, the strongest correlation was seen between Fairly Active + Very Active minutes and Matthews’ Lifestyle MVPA cut point ($r=.91$, deviation=9.5mins, deviation % about mean=8.3%).

*Estimation of ActiGraph Cut Points which most Closely Replicate Fitbit Estimated Physical Activity*

Table 4.2 summarizes the results for the estimation of the ActiGraph cut points which most closely replicate the minutes in various levels of physical activity from the Fitbit Zip monitor. Cut points were evaluated at both the group and individual level, but ultimately the findings were very closely matched. We found that the best matched ActiGraph cut points for Lightly Active, Fairly Active, and Very Active activity were 150cpm, 600cpm, and 2975cpm. The Sedentary/Lightly Active cut point was very similar to the current 100cpm used in many studies, while the Lightly Active/Fairly Active cut point was very close to the lifestyle MVPA cut point proposed by Matthew (81).

*Meeting National Recommendation for Steps*

The agreement for classification of steps meeting or not meeting the national recommendation of 10,000 daily steps was also examined in this study. It was found that the level of agreement was also high (88.6%) for the Fitbit Zip and ActiGraph. In total, both monitors classified 22 participants reaching 10,000 steps, and nine participants reaching less than 10,000 steps. Thus, there were four disagreements on 10,000 step attainment, resulting in a kappa = 0.74. For each disagreement, fewer steps were recorded by the ActiGraph and were
recorded as follows for ActiGraph vs. Fitbit Zip: 9589 vs. 10,094 steps, 8073 vs. 10,234 steps, 7340 vs. 10,010 steps, and 9096 vs. 11,218 steps.

*Self-reported Activity Outcomes*

All participants completed both the pre- and post-questionnaires. In response to the baseline question regarding activity in past week, 94% of participants reported engaging in moderate activity and 71% of participants reported engaging in vigorous activity. In the follow up survey, 80% of participants reported engaging in moderate activity the day of accelerometer wear, while 43% reported engaging in vigorous activity.

As additional validity evidence, we examined the correlations between various self-report physical activity outcomes and activity outcomes from the activity monitors (see Table 4.3). Correlations with step outcomes were nearly identical. Other relationships varied slightly between monitors when matched by intensity (*Fairly*+ *Very* Active with MVPA, *Very* Active with VPA, and *Lightly* Active+ *Fairly* Active+ *Very* Active with LMVPA). Ultimately, ActiGraph outcomes had slightly stronger relationships with self-report compared to those from the Fitbit.

**IV. E. Discussion**

Increasing trends in physical inactivity and sedentary time are strongly associated with increases in morbidity and mortality. As such, there has been renewed interest in behavioral programs that not only promote, but maintain physical activity. Research has shown that self-monitoring is an important component of successful behavioral change interventions. Thus, the surge in popularity of mobile activity trackers (85) has gained traction among researchers and
clinicians (86) as a potential way to not only promote activity, but to objectively monitor the amount and type of activity in real time.

The purpose of this study was to validate a commercially-available accelerometer, the Fitbit Zip, in a sample of free-living, healthy adults. The Fitbit was compared and contrasted to another commonly used and validated accelerometer, the ActiGraph GT3X. Because we were able to determine activity cut points using the ActiGraph, we also explored which cut points most closely matched with the Fitbit’s output in order to evaluate Fitbit’s classification of light, moderate and vigorous activity.

Overall, our findings indicate that the average steps recorded by the Fitbit Zip were strongly correlated with average daily steps recorded by the ActiGraph. While there was a strong linear relationship between the two monitors, we found that the Fitbit Zip consistently recorded about seven percent more steps than the ActiGraph. A similar step trend also emerged among the 15 minute block data where observed that the ActiGraph recorded slightly more steps than the Fitbit Zip at lower step values (<100 steps), but fewer steps than the Fitbit Zip for higher step values (>100 steps).

The observed deviation in average steps was unexpected given the findings from previous controlled validation studies which indicated non-significant step count differences (73-75). However, these differences may be a result of above ground activity versus treadmill-based activity. A study by Nagano and colleagues (87), found that there were significant differences in walking stride and step time when comparing these two activity mediums. Thus, future studies should explore in a larger sample how changes in speed in above-ground walking may affect step count accuracy of the Fitbit Zip.
It should be noted that while the current study population was primarily young, white, and female, a good deal of variability in activity level was observed. The number of steps per day ranged from 3,085 to 17,005, with a median value of 7,340 steps. While greater accuracy in step counts were observed for steps below 7,000 steps, a larger sample is needed to identify if this is a significant trend. Similarly, while no notable trend differences by body mass index was observed (data not shown), further work might explore if true differences do exist as suggested in pedometer studies (88).

The second purpose of this current study was to evaluate the Fitbit Zip’s classification of activity intensity and to determine how well it aligned with typical research activity cut points. It was estimated that the ActiGraph cut-point which most closely matched the Fitbit Zip’s estimate of Light, Fairly and Very Active activity minutes to be approximately 150cpm, 600cpm, and 2975cpm respectively. Using these count levels and a previously established estimate of metabolic equivalents (METs) from ActiGraph counts, these cutoffs occur at about 1.6 METs, 1.9 METs, and 3.8 METs (79, 89). These MET estimates suggest that Fitbit’s activity classifications align more closely with research defined light and moderate cut points (79, 81, 89, 90). Thus, it would appear that the Fitbit Zip’s classification of Very Active minutes includes what physical activity researchers and public health recommendations would consider moderate and vigorous activity. Thus, this combination of the Fairly Active and Very Active minutes make the Fitbit Zip an acceptable measurement tool for general healthy lifestyle activities.

The current study findings indicate that the Fitbit Zip’s algorithm does not appear to account for non-wear time (e.g., sleeping, water-based activities, etc.) (78). Not accounting for non-wear time can result in substantial misclassification of sedentary time. Because we calculated Fitbit Zip’s sedentary time based on non-wear time from the ActiGraph, it is possible
that our comparison of sedentary minutes is slightly biased. The non-wear time estimate from the ActiGraph data was used partially out of convenience; it is automatically estimated when processing the data, and because the two monitors were worn on the same elastic belt, it is very likely that if one monitor was removed, both would be removed. Post-hoc examination of the 15 min step data from the Fitbit Zip suggest that a similar algorithm could be applied to the Fitbit Zip data (i.e., 4-5 consecutive 15-blocks with 0 steps) to get a similar estimate of when the Fitbit Zip is not being worn. As interest in sedentary behavior grows and the importance of its connection to health is differentiated, separating sedentary and non-wear time in commercially available activity devices (even among those that have a sleep function) will become of greater importance.

Overall, the Fitbit Zip holds promise for its use in lifestyle based intervention studies. The validity evidence is strong for Fitbit Zip’s estimate of steps per day. The evidence supporting the Fitbit Zip’s quantification of Very Active minutes is also good, matching the ActiGraph calibration studies of Treuth (90) and Nichols (89) more closely than those from Freedson and Troiano (NHANES) (78). Researchers should be aware of these differences and take them into consideration when judging Fitbit Zip derived activity estimates within the larger context of the physical activity literature. Clinicians may find particular value in estimating participant activity through objective monitoring allowing for both real time and longitudinal data collection. Fitbit should consider incorporating non-wear identification and an additional classification of vigorous activities (above 6 METs) in the feedback they provide users. Future studies should continue to compare the variety of consumer-based activity trackers and models with monitors that have been used more in physical activity research.


Conclusion

The validity of the Fitbit Zip to record average steps taken and activity intensity among 35 free-living adults was evaluated in this current study. It was found that the Fitbit Zip consistently counted about 7% more steps the the Actigraph GT3X. While the Fitbit Zip’s classification of activity intensity did not match exactly with estimates from the Actigraph, the Fitbit Zip did appear to accurately measure research defined light and moderate activity (79, 81). Therefore, the results of this study suggests that the Fitbit Zip should be considered as meaningful tool for measuring objective, real-time physical activity in free-living adults who are able to ambulate without assistance. For more precise classification of activity intensity using the Fitbit Zip, more research is needed to test algorithms that accounts for non-wear time.
Table 4.1 Comparison between Fitbit and ActiGraph: Means, Correlation, Deviation, and Percent Mean Deviation

<table>
<thead>
<tr>
<th>Fitbit outcomes</th>
<th>Fitbit Mean± SD*</th>
<th>ActiGraph Outcomes</th>
<th>ActiGraph Mean± SD*</th>
<th>r</th>
<th>Signed Difference</th>
<th>Difference as % of Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steps</td>
<td>9268± 4134</td>
<td>Steps</td>
<td>8591.9± 3882.5</td>
<td>0.98</td>
<td>676.11</td>
<td>7.3%</td>
</tr>
<tr>
<td>15- minute Block</td>
<td>151.7± 313</td>
<td>15- minute block</td>
<td>141.8± 279.6</td>
<td>0.985</td>
<td>9.95</td>
<td>6.6%</td>
</tr>
<tr>
<td>Sedentary</td>
<td>1256.4± 55.4</td>
<td>Sedentary (&lt;100 cpm)</td>
<td>716.0± 85.6</td>
<td>-0.17</td>
<td>540.4</td>
<td>43.0%</td>
</tr>
<tr>
<td>ADJ Sedentary</td>
<td>731.6± 88.6</td>
<td>Sedentary (&lt;100 cpm)</td>
<td>716.0± 85.6</td>
<td>0.96</td>
<td>15.6</td>
<td>2.1%</td>
</tr>
<tr>
<td>Lightly Active</td>
<td>68.9± 24</td>
<td>Light (100 – 2019 cpm)</td>
<td>136.5± 43</td>
<td>0.71</td>
<td>-67.6</td>
<td>98.1%</td>
</tr>
<tr>
<td>Fairly Active</td>
<td>71.6± 29.6</td>
<td>Moderate (2020 – 5998 cpm)</td>
<td>54.4± 27.5</td>
<td>0.26</td>
<td>17.1</td>
<td>23.9%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lifestyle MVPA (760+ cpm)</td>
<td>105.2± 37.3</td>
<td>0.50</td>
<td>-33.6</td>
<td>46.9%</td>
</tr>
<tr>
<td>Very Active</td>
<td>43.1± 30.3</td>
<td>Vigorous (5999+ cpm)</td>
<td>6.4± 11.3</td>
<td>0.54</td>
<td>36.7</td>
<td>85.2%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MVPA (2020+ cpm)</td>
<td>60.8± 33.2</td>
<td>0.89</td>
<td>-17.7</td>
<td>41.1%</td>
</tr>
<tr>
<td>Lightly+ Fairly Active+ Very</td>
<td>183.6± 55.4</td>
<td>Non-sedentary (100+ cpm)</td>
<td>197.3± 21.9</td>
<td>0.89</td>
<td>-13.7</td>
<td>7.5%</td>
</tr>
<tr>
<td>Active</td>
<td></td>
<td>MVPA (2020+ cpm)</td>
<td>60.8± 33.2</td>
<td>0.80</td>
<td>53.9</td>
<td>47.0%</td>
</tr>
<tr>
<td>Fairly Active+ Very Active</td>
<td>114.7± 43.8</td>
<td>MVPA (2020+ cpm)</td>
<td>105.2± 37.3</td>
<td>0.91</td>
<td>9.5</td>
<td>8.3%</td>
</tr>
</tbody>
</table>

*All Mean (SD) values are reported in minutes, except for steps.

Data extracted from the following sources: a= Fitbit Website, b= calculated using ActiGraph non-wear minutes, c= ActiGraph, d=NHANES cut points, e= Matthew cut point; “difference as % of Mean was computed as (|signed difference|/Fitbit Mean).
Table 4.2 Estimating best individual and group cut points for each Fitbit intensity category

<table>
<thead>
<tr>
<th>Fitbit Outcome (minutes)</th>
<th>GROUP</th>
<th>INDIVIDUAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Best Cut (cnts)</td>
<td>Best DEV (min)</td>
</tr>
<tr>
<td>Light, Fairly Active, &amp; Very Active</td>
<td>150</td>
<td>2.58</td>
</tr>
<tr>
<td>Fairly Active &amp; Very Active</td>
<td>600</td>
<td>2.14</td>
</tr>
<tr>
<td>Very Active</td>
<td>2900</td>
<td>0.35</td>
</tr>
</tbody>
</table>

**Cnts** = Activity Counts, **CV** = Coefficient of Variation, **Dev** = Deviation.
Table 4.3 Correlations between self-report minutes and objective minutes from the Fitbit & ActiGraph

<table>
<thead>
<tr>
<th>Self- Report Variables</th>
<th>Fitbit Steps</th>
<th>ActiGraph Steps</th>
<th>Fitbit Fairly+</th>
<th>ActiGraph MVPA</th>
<th>Fitbit Very Active</th>
<th>ActiGraph VPA</th>
<th>Fitbit Light+</th>
<th>ActiGraph LMVPA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baseline</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MVPA min</td>
<td>0.23</td>
<td>0.24</td>
<td>0.18</td>
<td>0.23</td>
<td>0.21</td>
<td>0.21</td>
<td>0.26</td>
<td>0.26</td>
</tr>
<tr>
<td>VPA min</td>
<td>0.23</td>
<td>0.26</td>
<td>0.18*</td>
<td>0.32*</td>
<td>0.21</td>
<td>0.21</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td><strong>Follow-up</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sitting</td>
<td>-0.25</td>
<td>-0.20</td>
<td>-0.33</td>
<td>-0.06</td>
<td>-0.13</td>
<td>0.003</td>
<td>-0.33</td>
<td>-0.32</td>
</tr>
<tr>
<td>TV</td>
<td>0.14</td>
<td>0.06</td>
<td>0.16</td>
<td>0.09</td>
<td>0.06</td>
<td>-0.04</td>
<td>0.07</td>
<td>0.04</td>
</tr>
<tr>
<td>MVPA min</td>
<td>0.58</td>
<td>0.59</td>
<td>0.42</td>
<td>0.50</td>
<td>0.58*</td>
<td>0.33</td>
<td>0.41</td>
<td>0.51</td>
</tr>
<tr>
<td>VPA min</td>
<td>0.43</td>
<td>0.43</td>
<td>0.32</td>
<td>0.40</td>
<td>0.31</td>
<td>0.57*</td>
<td>0.31</td>
<td>0.34</td>
</tr>
</tbody>
</table>

*= stronger correlations observed between self-report variable and ActiGraph or Fitbit.

ACT=ActiGraph, Fairly+= Fairly Active minutes+ Very Active minutes, Light+= Lightly Active+ Fairly Active+ Very Active, MVPA= Moderate to Vigorous Activity, VPA= Vigorous Physical Activity, LMVPA= Light, Moderate, and Vigorous Physical Activity.
Figure 4.1: Bland-Altman Plot demonstrating level of step agreement between the Fitbit and ActiGraph.

Average Coefficient of Deviation= 6.6(5.5)%; 90% of sample within 1363.51 steps, and 80% of sample within 1060.97 steps.
Figure 4.2 Bland-Altman Plot comparing 15-minute intervals between 05:00-23:59 for two accelerometers.

Average Coefficient of Deviation= 70.9(61.5)%; 90% of sample within 101.81 steps, and 80% of sample within 79.22 steps for 15-minute blocks.
Figure 4.3 Step deviations* across count level for the Fitbit and ActiGraph **

*Deviation = Fitbit steps minus ActiGraph steps; **Figure truncated so the differences at the lower count levels can be visually differentiated (data table upon request).
CHAPTER V: FEASIBILITY OF A WEB-BASED, TAILORED INTERVENTION TO INCREASE WALKING STEPS AMONG A NATIONAL SAMPLE OF BREAST CANCER SURVIVORS

V. A. Overview

Traditional physical activity interventions are often limited in reach and accessibility, and may miss the individual needs of a participant. A web-based, tailored intervention may address these limitations. Because few studies have investigated these approaches among cancer survivors, this study reports the feasibility of an online, tailored intervention to increase walking steps among post-treatment breast cancer survivors (BCS).

Ninety BCS, recruited through social media and other methods, were randomized to a 12-week intervention where they received either tailored or targeted weekly emails. Fitbit Zips and self-report questionnaires assessed physical activity. Cohen’s d effect sizes and mixed models evaluated change in steps, and linear regression evaluated step goal achievement.

BCS were recruited primarily via social media and email listservs. We demonstrated good to excellent weekly compliance (70-89%), and low rates of attrition (7%). The tailored group fared better than the target group for step goal achievement at weeks 10, 11, and 12 (p<0.05), and engaged in more objective steps at intervention midpoint (p=0.03). We observed moderate effect sizes for differences in steps at intervention midpoint (d=0.49) and follow-up (d=0.63), as well as significant differences in self-reported screen time (p=0.03).
Tailoring is an effective technique to promote walking steps, reduce sedentary time, and increase goal-setting behaviors. Future studies should explore the efficacy of such a program in a larger sample, and evaluate post-intervention maintenance.

A self-directed, web-based intervention is an acceptable and feasible approach to reach and recruit inactive BCS and promote moderate changes in activity.
V.B. Introduction

There are nearly three million breast cancer survivors living in the United States today, and this number is expected to grow to 3.7 million by the year 2022 (17, 91). While these trends in survival are encouraging, post-treatment care is becoming increasingly important as we learn more about the long-term side effects of breast cancer treatment. A recent study by Schmitz and colleagues (1) revealed that more than 60% of breast cancer survivors live with at least one side-effect of treatment, even six years after diagnosis. The type of long term side-effects commonly reported by breast cancer survivors range from physical (weight gain, fatigue, weakness, lymphedema, etc.) to psychosocial (mental, emotional, and sexual health), and typically span the cancer care continuum (1).

However, many of the physical and psychosocial side effects of cancer treatment may be mitigated through engagement in regular physical activity (26, 92, 93). As such, national physical activity guidelines suggest that some activity is better than none, and specifically recommend that breast cancer survivors engage at least 30 minutes of daily moderate to vigorous activity (MVPA) (94). This recommendation, in addition to habitual daily activity, equates to approximately 7,000-10,000 steps/day (10). Despite these recommendations, less than one third of post-treatment breast cancer survivors engage in adequate levels of weekly activity (4, 5, 81, 95), and more than two-thirds are classified as sedentary (96).

Self-directed interventions, which target increased activity, hold promise in reaching more breast cancer survivors than traditional interventions, especially with the increasing popularity of web and mobile health tracking tools (e.g. Fitbit, Jawbone) (6, 85). However,
current self-directed interventions often come in a one-size-fits-all package, which may miss the individual needs of a breast cancer survivor.

Inclusion of a tailored messaging approach may address these individual needs. Tailored messages can customize behavioral programs by creating messages that are based on an individual’s unique behavioral characteristics and needs. This is in contrast to a tailored message approach which relies on the general characteristics of a target population (7). For example, an inactive breast cancer survivor is more likely to modify their activity based on a message that incorporates their personal physical activity barriers, as opposed to a general message that incorporates typical physical activity barriers experienced by the majority of breast cancer survivors (39).

Not surprisingly, inclusion of tailored messages in traditional behavioral change interventions has shown success. One such trial among newly diagnosed breast and prostate cancer survivors incorporated tailored messages in monthly newsletters to promote regular activity and increased fruit and vegetable consumption. The study ultimately demonstrated that tailored messages significantly increased self-reported minutes of physical activity (increase of 59.3 (39.2) minutes), and consumption of fruits and vegetables (increase of 1.1 (0.6) servings) (62). Similar positive results have been confirmed in large meta-analyses exploring the use and delivery of tailored and targeted messages (39, 97).

However, with the movement towards developing more accessible behavioral interventions, there is a growing need for tailored physical activity programs that incorporate both web- and mobile-based technologies (98). Currently, there are few physical activity studies that have evaluated the feasibility of developing and implementing such a program. Furthermore,
no physical activity interventions have explored the added benefit of using objective activity monitoring information to tailor and revise weekly activity goals based on real-time feedback.

Thus, the purpose of this study is to determine the feasibility of a 12-week randomized trial to increase physical activity among inactive post-treatment breast cancer survivors by providing theory-guided feedback, as well as weekly tailored activity goals based on objective physical activity data. We also sought to determine if tailoring would result in greater weekly step goal achievement when compared to targeted weekly emails (comparison group). For this study, physical activity was assessed using online self-reported questionnaires, as well as a validated commercial accelerometer, the Fitbit Zip (Kaye et al., Under Review).

V.C. Methods

Setting and Participants

Between July and November 2013, post-treatment breast cancer survivors living in the United States were recruited via email listservs, social media postings by breast cancer survivorship support groups, website announcements, targeted advertisements via social media (e.g., Facebook, Twitter), flyers emailed and posted to appropriate cancer organizations and hospitals, and invited radio interviews (XM Radio). Recruitment advertisements directed interested participants to the study website which provided additional details about the study, eligibility criteria, and a link to the online screening questionnaire.

Inclusion criteria

Participants were eligible for the study if they met the following eligibility criteria: female with a history of breast cancer ≤stage II, 2-10 years post treatment completion (BCSs
undergoing hormonal treatment were eligible), no evidence of secondary cancers, BMI between 18-40 kg/m², physically active less than 30 minutes, 3 days per week per Stanford Brief Activity Survey (99, 100), between 40-70 years of age (increased injury risk related to increasing age and older adults (9)), able to read English, able to ambulate without assistance, not concurrently enrolled in another physical activity/ weight loss program, no concurrent medical conditions precluding participants from engaging in regular activity (PAR-Q (101)), U.S. resident, and regular access to the internet/computer and an email account. For the assessment of physical activity readiness (evaluation of cardiovascular risk factors) using the PAR-Q, the question regarding blood pressure medication was removed given that breast cancer therapy and hormonal treatments often result in elevated blood pressure (102).

Study design

This was a 12-week, two-arm, randomized trial designed to increase activity among inactive post-treatment breast cancer survivors. Eligible participants were emailed a link to the online study consent form which described the aim of the study, what participants were being asked to do, and potential risks and benefits. Only those participants who provided online consent were emailed a link to the baseline questionnaire. Study enrollment was done on a rolling admissions basis.

Following baseline data collection, participants were mailed a package, which included a Fitbit Zip and set-up instructions. Once a participant had set up their Fitbit, they were block randomized into either the intervention (tailored emails), or comparison group (targeted-only emails). Randomization was further stratified by participants who reported taking Aromatase
Inhibitors (yes/no), as AI’s may cause joint pain which may in turn impact physical activity (103). All study participants were blinded to their group assignment.

During the study, participants were asked to wear their Fitbit daily (and sync every 2-3 days), read weekly emails, and complete additional online questionnaires at the midpoint of the intervention and at one week following the completion of the 12-week program. Weekly data was collected on Saturday, and emails were sent on Sundays. Participants who did not sync and/or wear their Fitbit, or who did not complete the online questionnaires, as outlined in the protocol, were contacted by a member of the research team via email or telephone to encourage participation. At the completion of all study questionnaires, participants received a $20 Amazon.com gift card.

This study was approved by the UNC Institutional Review Board (IRB # 13-2370) and the Lineberger Comprehensive Cancer Center’s Protocol Review Committee (LCCC 1313).

Intervention Procedures

Email Development

Prior to the start of the randomized trial, we developed and evaluated the written content to be used in the weekly emails. All emails were framed in the context of female breast cancer survivorship, and information was based on credible resources (e.g., National Cancer Institute, American Cancer Society), as well as the most current physical activity recommendations for breast cancer survivors (2). Weekly email topics addressed physical activity barriers, setting and achieving weekly step goals, building social support, reducing sedentary time, resistance training and stretching, enjoying activity, and eating well. Email layout and content were similar between groups, with the exception of the tailored or targeted message components.
**Tailored Messages.** Participants in the intervention group received weekly emails that provided personalized feedback on step goal achievement, as well as tailored step goals. Feedback was tailored to whether a participant achieved their weekly step goal, did not achieve their weekly step goal, or if they did not wear/sync their Fitbit.

Tailored step goals were based on the previous week’s average step performance, and increased in increments of 500 to 750 steps per week (104, 105). If a participant did not wear/sync their Fitbit, then the previous week’s step goal was used. If a participant reached the national recommendation of 10,000 daily steps during the course of the study, the focus of the weekly emails shifted to maintaining step achievements.

Feedback messages drew on constructs from the Social Cognitive Theory (41) and the Self-determination Theory (106), and thus, were framed to provide positive feedback, emphasize choice/ control, and encourage proximal goal-setting and activity self-monitoring. A similar approach was used to address any physical activity barriers reported at baseline and intervention midpoint, but the emphasis for these messages shifted to problem-solving and building of social support.

**Targeted Messages.** Participants in the comparison group received similar weekly emails, but these were not tailored on any variables. Rather, targeted emails informed participants of their average weekly step achievements, but no interpretation/ feedback was given. Suggested weekly goals were not tailored on the previous week’s step performance, but rather were based on standard recommendations for starting a walking plan (107). Step goals were set such that in the first week participants were given the goal of 3500 daily steps, in the second week, 4500 daily steps, and then encouraged to increase goals by 500 steps per week over the remainder of the intervention.
Message Testing

In order to evaluate the content developed for the weekly emails, we recruited 13 sedentary women, aged 40-65 years, to complete an online questionnaire. Through a series of open and closed questions, participants evaluated the content for acceptability, trust, importance, accuracy, engagement, and burden (108). Overall, participants rated the email content favorably, and suggestions were used to tweak the email layout, as well as the tailored and targeted messages.

Fitbit Set-up

All study participants received a Fitbit Zip to track daily step activity. Participants were asked to set up their Fitbit with an email of choice and were assigned a study password. No identifying information other than the participant’s first name, weight, and height were entered into the Fitbit website by the study team.

Prior to the start of the intervention, participants were asked to wear their Fitbit for a one-week run-in period. During this time, participants were instructed to maintain their usual activity and to report any difficulties using the Fitbit provided.

Following the run-in period, participants began receiving weekly emails. Data collected by the Fitbit were used to set weekly tailored goals, thus participants were encouraged to sync their Fitbit every 2-3 days. Additional tailoring of emails was done using self-reported physical activity barriers from baseline and midpoint questionnaires.

Measures

Demographics. At baseline, basic demographic information (age, race, education, household income, occupation, marital status, smoking status), and cancer history (year of
diagnosis, stage of cancer, type of treatment, time since completion of primary treatment, hormonal treatment status) were assessed. Body mass index (BMI) was calculated using self-reported height and weight. A single question also asked participants to rate their overall health status.

Physical activity. Baseline physical activity and change in weekly objective steps were measured using data recorded from the Fitbit Zip. The Fitbit Zip (Fitbit, Inc., San Francisco, CA) is a small, validated (Kaye et al., 2014, Under Review), commercial device that tracks user activity in real time. Users can access their data either by tapping on the Fitbit screen, or syncing their device and accessing data through their personal Fitbit webpage.

For this study, a computer program was developed to automatically retrieve Fitbit activity data following participant syncing. Activity data included daily steps, distance traveled, and activity intensity (lightly, fairly and very active). For the purposes of this feasibility study, only step data were used. Data collected were used to track step goal attainment, and set weekly step goals depending on group assignment.

Self-reported physical activity was assessed using the Godin Leisure Time Exercise Questionnaire (GLTEQ) (109). The GLTEQ is a four-item instrument evaluating mild (minimal effort, e.g., yoga, easy walking), moderate (e.g., fast walking, easy swimming/ cycling), and strenuous (e.g., running, jogging) activity completed in the last seven days. In order to calculate minutes of activity, we modified the questionnaire to include three additional questions pertaining to the length of time spent in each type of activity (110). Sedentary behavior was evaluated using one question on sitting time (During the last 7 days, how much time did you usually spend sitting?) (82), and one question on television/ screen viewing time (Over the past
30 days, in your leisure time, how many hours per day, on average, did you sit and watch TV or movies, surf the web, or play computer games?) (111).

**Outcome and process data.** Over the course of the study, participant recruitment was tracked from baseline questionnaires which asked a single question on where participants had first learned about the study. Participant retention and attrition over time were based on available Fitbit data, as well as completion rates for the midpoint and follow-up questionnaires. Finally, participants were asked to evaluate how well the intervention tools (Fitbit monitor and weekly emails) motivated them throughout the study, how well the study applied to their lives, and if they would recommend such a study to other breast cancer survivors.

**Statistical Analyses**

All data analyses were conducted using SAS statistical software (version 9.3, Cary, NC). Sample size was calculated using a two-group independent t-test with 80% power, and alpha=0.05 to detect a mean difference of 650 steps (SD=1000) between groups. Based on these calculations, 78 evaluable participants would be needed. Therefore, accounting for a 15% attrition rate, a recruitment target of 90 participants (45 per group) was established.

Descriptive analyses compared groups at baseline using independent t-tests for continuous variables, and/or Chi-square/ Fisher Exact Tests for categorical variables. Similar analyses were conducted for participants who did not complete the study.

Change in objective and self-reported activities were assessed using Cohen’s d calculations (112), and mixed model analyses. In mixed models analyses, covariates included baseline age, time since diagnosis, stage of breast cancer diagnosis, and BMI. For step data to be valid, at least four days of data per week (with step values >100 steps for each day used) were
required. Differences in step goal achievement (# participants meeting goals) by group was evaluated using linear models for each week of the intervention.

Any missing data in mixed models were considered to be missing completely at random and maximum likelihood estimates were used in place of imputation. An alpha level was set \textit{a priori} at 0.05 for all analyses and statistical significance was determined using \( p < 0.05 \) (two-tailed).

\textbf{V.D. Results}

\textit{Recruitment and Enrollment}

A total of 689 interested participants completed the online screener between July and November 2013, of which 114 (16.5\%) participants were eligible. Six percent of eligible participants declined to participate, and the remainder were excluded for the following reasons: less than two years (22\%) or more than 10 years (6\%) post-treatment completion; not meeting inactivity criteria (11\%); > stage II breast cancer diagnosis (13\%); answering affirmatively to one or more questions on the PAR-Q (14\%); not meeting age criteria (9\%) or BMI (6\%) criteria; lack of computer/internet access/comfort (6\%), and Other (not a US resident, not female, currently receiving treatment) (7\%).

Participants were recruited primarily via Facebook advertisements (newsfeed and side-bar advertisements), and Facebook page announcements (41.1\%). Facebook advertisements were targeted towards English-speaking US females (40+ years of age) who had also indicated that they were part of a breast cancer organization. Facebook newsfeed advertisements had better click-through rates to the study website than the side-bar advertisements (3.7\% vs. 0.02\%). Other
recruitment methods that were fairly successful included email listserv announcements (22%), and friend/family member (17%). Flyers did not generate any recruitment.

Of the 114 eligible participants, 90 participants consented to the study and completed the baseline questionnaire and Fitbit monitor set-up (Fig. 5.1). Following set-up, 44 participants were randomized to the tailored group, and 46 participants were randomized to the target group.

Baseline Characteristics

Participants were primarily non-Hispanic white (97.7%) females, with a mean age of 55.0±7.3 years. Participants were enrolled primarily from North Carolina (14.4%), Texas (12.2%), California (11.1%), and New York (6.7%). On average, participants were 4.3 ± 2.1 years post treatment completion, 21% were receiving Aromatase Inhibitors, and most considered their health to be good to very good (85.6%). There were no differences in baseline characteristics between groups, although there was a trend toward significance for age (p=0.06) (Supplemental Table 5.1).

Change in Steps

At baseline, there were no differences between the average number of weekly steps taken by the tailored group compared to the targeted group (p=0.25). At intervention midpoint, we observed a moderate difference between groups for average daily steps taken (effect size, \(d=0.49\)), with the tailored group taking ~1600 more steps than the targeted group. At one week post-intervention, we observed a slightly stronger effect size (\(d=0.63\)) between groups, with the tailored group taking ~1900 more daily steps than the targeted group (Fig. 5.2).
Over the course of the study, the tailored group consistently took more daily steps on average than the targeted group for each week of the study, with a summed average difference of 13,321 steps (~1,110 average additional daily steps per week). Examination of differences in total steps for participants with complete step data for each week of the study (n= 56) revealed that the tailored group took 1252.2 more steps per day than the targeted group for each study week (p=0.05). Furthermore, although only a small number of participants reached 10,000 daily steps in the final intervention week, the tailored group reached this goal slightly more often than the targeted group (n=12, 58% vs. 42%).

In mixed models adjusted for time and group only (Supplemental Fig.5.1), significant step differences between groups were observed at intervention midpoint (1427 steps, SE=663.82, p=0.03), but not at one-week follow-up. Trends towards significance between groups were observed at week 8 (p= 0.09) and week 10 (p= 0.09). Inclusion of baseline steps in the model resulted in non-significant changes in steps between groups for all weeks (data not shown, overall model: p=0.68).

Change in Self-reported Physical Activity

Between baseline and follow-up, the tailored group reduced their screen time significantly more than the targeted group (p=0.02) (see Table 5.1). We also observed significant changes within groups over time for sitting time, MVPA, and total activity; however, differences between groups were non-significant (p = 0.663, 0.424, and 0.682, respectively).
Weekly Step Goals

At the start of the study, the target group met their step goal significantly more often for each week of the study than the tailored group; this was likely due to the fact that the pre-defined step goals for the target group were significantly lower than the tailored group (see Table 5.2). Towards the study midpoint (weeks 6 and 7), there were no significant differences between groups for goal attainment, with the tailored group setting significantly larger step goals than the target group. Finally, in the last month of the study, trends in step achievement were reversed such that the tailored group began achieving their weekly step goals significantly more often than the targeted group for each week, even when step goals were not significantly different between groups (week 10).

Adherence

Fitbit and Questionnaires Adherence was similar between tailored and targeted groups for each week of the study. At the study midpoint, 86.7% of participants were wearing and syncing their Fitbit, and 87.8% had completed the midpoint questionnaire. Similar adherence rates were observed for the remainder of the intervention (weeks 7-12) where at least 77.8% participants were wearing and syncing their Fitbit. However, at one-week follow-up, there was a sharp drop in the number of participants who had worn and synced their Fitbit (56.7%). This was unexpected given the strong response rates for the follow-up questionnaire (89%). Comparison of study completers and non-completers revealed no significant baseline differences between groups (see Supplemental Table 5.4).

Days of Fitbit Wear There were no significant differences in the number of days of Fitbit wear between groups at baseline (p=0.69) and follow-up (p=0.47). However, participants wore
their monitors significantly less at one-week follow-up than at baseline (tailored group: baseline 6.18 ±1.05 days vs. follow-up 4.5 ±2.72 days, p<0.001; targeted group: baseline 6.27 ±1.12 days vs. follow-up 4.05 ±3.1 days, p<0.001).

Attrition

Following randomization, one participant from the tailored group, and four participants from the target group did not sync/wear their Fitbit for at least four days (three did not sync data, one was not compliant), and thus were classified as not having valid baseline step data. During the study, two participants withdrew from the tailored group citing unrelated medical reasons and lack of interest.

Process Measures

In the follow-up questionnaire, participants reported that their strongest motivation to exercise came from the Fitbit monitor (4.61 ±0.79), and felt only somewhat motivated by weekly emails (3.34 ±1.2), and setting of weekly goals (3.36 ±1.34). There were no significant differences in self-reported motivation between the tailored and targeted group for the Fitbit monitor (p=0.32), weekly emails (p=0.93), and weekly goal setting (p=0.16).

Furthermore, participants reported that the Fitbit monitor strongly applied to their lives (4.41 ±0.92), whereas the weekly emails only moderately applied (3.41 ±1.05). Again, no significant differences were observed between tailored and targeted groups for either variable (data not shown).

Finally, both groups reported that they felt that 12-week intervention was designed for someone like them (4.45 ±0.99, p=1.00), that they enjoyed participating (4.73 ±0.59, p=0.57),
and that they would very likely recommend such a study to another breast cancer survivor (4.79 ±0.59, p=0.57).

V.E. Discussion

This study was one of the first behavioral interventions with automated monitoring and tailored feedback to promote physical activity among breast cancer survivors. The results of the study demonstrated that such an intervention can be implemented with promising success using only web-based applications. Furthermore, use of a tailored approach had an added benefit over a targeted approach in supporting physical activity.

Given the growing support for web-based recruitment (113, 114), we utilized a multi-method approach, recruiting participants via social media, electronic announcements, and even more traditional methods, like flyers and word of mouth. Ultimately, we found that use of social media (especially Facebook advertisements and announcements) was the most effective in reaching our target audience (115). However, while social media can be a very effective technique for recruitment, we were also aware of the importance of not only differentiating our study from the myriad of commercial advertisements, but also building credibility. As such, we took great care in ensuring that our recruitment advertisements highlighted only the research and behavioral aspects of the study, rather than the study incentive (e.g., the Fitbit). The study also had a separate .org website and listed links and information about the research team and any approvals received from ethics committees.

While web-based, self-directed interventions can be more advantageous in reaching survivors than traditional face-to-face, or paper-based interventions, one disadvantage can be high rates of attrition (116, 117). Privy to this, strategies to improve participant engagement
throughout the study and, consequently, improve rates of retention were sought. Research has shown that self-monitoring is one of the strongest predictors of behavioral adherence (37, 118), and as such, all study participants were provided with a commercial physical activity tracker, the Fitbit. However, the Fitbit did not serve only as an intervention tool, but also as an outcome measure. Data collected from the Fitbit were used to assess weekly activity, re-tailor weekly activity goals, and gain important insights on how participant step activity changed over time—an advancement on prior behavioral intervention trials. Overall, participants responded favorably to the use of the Fitbit, with the exception of one participant who had difficulty syncing her monitor despite numerous attempts to get her on track, and three participants who received the Fitbit, but never completed the one week run-in period.

However, while we observed good to excellent compliance rates over the course of the study for the wearing and syncing of the Fitbit, an unusual drop in the number of participants who had complete Fitbit data at one-week follow-up was noted. This sudden drop was perplexing especially given the excellent response rates for the follow-up questionnaire. Upon further review, it appeared that the likeliest explanation was that participants were ill-informed of the need to wear and sync their Fitbit in the week following the intervention. As such, future studies should take care in communicating study procedures especially towards the end of an intervention.

As noted earlier, changes in physical activity behavior was also observed during the study. It was found that the tailored group took, on average, 1,000 more steps per week (for each week of the study) compared to target group participants. The U.S National Physical Activity Guidelines suggest that even small increases in step activity can have health benefits, and that some activity is better than none (9). Blair and colleagues go as far as to suggest that simply
moving beyond sedentary step behavior (<5000 steps/day) to even just one step category higher (e.g., 5000-7499 steps), can have beneficial health outcomes (10, 119).

Over the course of the study, changes in goal-achievement were also observed. At the beginning of the study, the target group achieved their weekly step goals more often than the tailored group. This was not unexpected given that the weekly target goals were much lower than the weekly tailored goals initially; and second, baseline steps for the target group were well-above initial target goals set. However, as the study progressed, a shift in goal attainment was observed, especially at weeks 10, 11, and 12, where the tailored group achieved weekly goals significantly more often than the target group. These findings were particularly encouraging as they suggest that there is an added benefit to adjusting weekly step goals based on an individual’s weekly step achievement. However, further research is warranted given the mixed support (39, 120, 121) in the literature which currently suggests that this added benefit might not be observed in populations with higher baseline step activity (122).

Finally, the results of the study showed that the tailored group decreased their screen time significantly more than the target group between baseline and follow-up. In a systematic review of sedentary behavior and health outcomes among adults, Thorp and colleagues demonstrated that sedentary behavior is a strong risk factor for a host of diseases, including cardiovascular disease (CVD), for which breast cancer survivors are at particular risk (123). While additional studies are needed to explore the link between reduced sedentary time and CVD risk among breast cancer survivors, it is known that reduction in sedentary behaviors, like screen time, results can result in improved long-term health (92, 93).
**Strengths & Limitations:**

This study was designed to target inactive breast cancer survivors, but ultimately, about half of our study sample was fairly active at baseline despite screening attempts. While a validated screening tool was used, future studies should explore alternative screeners that evaluate minutes of activity, or consider using an alternative screening tool and/or verification system (e.g., telephone screening in addition to an online screener). Furthermore, despite efforts to recruit a racially diverse sample via minority organizations and targeted advertising, the study sample was primarily Caucasian. Future studies might explore alternative routes to reach minorities and assess if social media is an appropriate approach.

Of course, while racial diversity remains an issue in survivorship studies, the current study was also limited to those participants who had both regular access to, and comfort using a computer and the internet thus potentially biasing our sample. However, with the ever-increasing adoption of computer and mobile-based technologies, this may become less of a concern for aging breast cancer survivors (34, 85). Finally, assessment of physical activity outcomes using mixed models were largely limited by our sample size, thus larger samples are needed to evaluate if the preliminary findings of this study are not only statistically significant, but clinically meaningful as well. Future studies with larger samples should also explore change in objective physical activity patterns over time, and how these patterns change based on the frequency and type of tailoring used.

Despite these limitations, this study had a number of strengths. First, this study was a randomized trial allowing us to determine the causal relationship between tailoring and behavioral outcomes. Second, intervention costs were greatly reduced with the utilization of mobile and web-based technologies, which incidentally also allowed the research team to reach
large numbers of breast cancer survivors across the U.S in a relatively short time-period. Third, the intervention was guided by key behavioral theories that have demonstrated effectiveness in physical activity trials. And finally, a major strength of this study was the collection and use of real-time, objective, physical activity data allowing the research team to not only tailor weekly activity goals, but also gain valuable insights into patterns of participant activity.

**Conclusion**

Inactive, post-treatment, breast cancer survivors are an at-risk population for long-term physical and psychosocial side effects of cancer treatments. Ultimately, this study demonstrated that a self-directed, tailored physical activity intervention may offer a feasible alternative to traditional physical activity interventions with the potential of reaching large numbers of survivors. Furthermore, this study demonstrated that a tailored program may be delivered solely through web- and mobile-based technologies, reducing intervention cost and resources. Future studies are needed to evaluate the efficacy of such a trial in a larger sample, and determine if study effects are maintained over time.
Figure 5.1 Consort statement for the flow of participants through the study.

*Loss to one-week follow-up refers to Fitbit use only.
Figure 5.2 Unadjusted change in average daily steps (by week) between groups.

Abbreviations: BL= baseline, F/U= One-week follow-up

Participants per week (n= Tailored, n= Targeted): **BL**: 43,42; **W1**: 43,43; **W2**: 43,43; **W3**: 39,39; **W4**: 40,38; **W5**: 40,39; **W6**: 39,39; **W7**: 37,39; **W8**: 38, 37; **W9**: 38, 37; **W10**: 39,34; **W11**: 36,34; **W12**: 36,34; **FU**: 26, 25
Table 5.1 Baseline means and estimated mean changes in physical activity and sedentary time (screen, sitting) from maximum likelihood repeated measure models

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Baseline Mean (SE)</th>
<th>Follow-up Mean (SE)</th>
<th>Mean Change Mean (95% CI)</th>
<th>Time p</th>
<th>Group*Time p</th>
<th>Adjusted Mean Change Mean (95% CI)*</th>
<th>Time p</th>
<th>Group*Time p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MVPA (min/week)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tailored</td>
<td>78.59 (13.66)</td>
<td>152.19 (14.54)</td>
<td>73.60 (40.72, 106.49)</td>
<td>&lt;.0001</td>
<td></td>
<td>70.56 (37.23, 103.90)</td>
<td>&lt;.0001</td>
<td></td>
</tr>
<tr>
<td>Targeted</td>
<td>60.68 (13.97)</td>
<td>113.72 (14.57)</td>
<td>53.04 (19.93, 86.15)</td>
<td>0.0021</td>
<td></td>
<td>51.55 (18.35, 84.75)</td>
<td>0.0028</td>
<td></td>
</tr>
<tr>
<td><strong>Mild PA (min/week)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tailored</td>
<td>87.39 (16.42)</td>
<td>120.20 (17.36)</td>
<td>32.81 (-2.91, 68.53)</td>
<td>0.0713</td>
<td></td>
<td>33.84 (-2.40, 70.09)</td>
<td>0.0668</td>
<td></td>
</tr>
<tr>
<td>Targeted</td>
<td>53.18 (16.79)</td>
<td>88.98 (17.44)</td>
<td>35.80 (-0.12, 71.71)</td>
<td>0.0507</td>
<td></td>
<td>34.81 (-1.22, 70.84)</td>
<td>0.0581</td>
<td></td>
</tr>
<tr>
<td><strong>Total PA (min/week)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tailored</td>
<td>165.98 (21.71)</td>
<td>269.79 (23.11)</td>
<td>103.82 (51.53, 156.10)</td>
<td>0.0002</td>
<td></td>
<td>101.11 (47.96, 154.27)</td>
<td>0.0003</td>
<td></td>
</tr>
<tr>
<td>Targeted</td>
<td>113.86 (22.20)</td>
<td>202.33 (23.16)</td>
<td>88.47 (35.82, 141.11)</td>
<td>0.0013</td>
<td></td>
<td>85.66 (32.72, 138.60)</td>
<td>0.0019</td>
<td></td>
</tr>
<tr>
<td><strong>Screen Time (hr/week)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tailored</td>
<td>3.26 (0.20)</td>
<td>2.40 (0.21)</td>
<td>-0.86 (-1.29, -0.42)</td>
<td>0.0002</td>
<td></td>
<td>-0.85 (-1.29, -0.41)</td>
<td>0.0003</td>
<td></td>
</tr>
<tr>
<td>Targeted</td>
<td>2.95 (0.21)</td>
<td>2.80 (0.22)</td>
<td>-0.15 (-0.59, 0.29)</td>
<td>0.4954</td>
<td></td>
<td>-0.15 (-0.59, 0.29)</td>
<td>0.4907</td>
<td></td>
</tr>
<tr>
<td><strong>Sitting Time (hr/week)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tailored</td>
<td>4.50 (0.16)</td>
<td>4.05 (0.17)</td>
<td>-0.45 (-0.75, -0.14)</td>
<td>0.0047</td>
<td></td>
<td>-0.43 (-0.74, -0.12)</td>
<td>0.0071</td>
<td></td>
</tr>
<tr>
<td>Targeted</td>
<td>4.55 (0.17)</td>
<td>4.01 (0.17)</td>
<td>-0.53 (-0.84, -0.22)</td>
<td>0.0009</td>
<td></td>
<td>-0.53 (-0.84, -0.22)</td>
<td>0.0010</td>
<td></td>
</tr>
</tbody>
</table>

Number of participants for all models was: Tailored, baseline=44 (follow-up= 40); Targeted, baseline= 46 (follow-up= 40).

*Models adjusted for baseline age, time since diagnosis, stage of breast cancer at diagnosis, and BMI.
Table 5.2 Average Step Goals and Percentage of Participants Achieving Weekly Step Goal

<table>
<thead>
<tr>
<th>Week</th>
<th>n&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Tailored Message</th>
<th></th>
<th>Targeted Message</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>41</td>
<td>6641.15 (2928.67)*</td>
<td>26 (63.4)</td>
<td>43</td>
<td>3500 (0)</td>
</tr>
<tr>
<td>2</td>
<td>41</td>
<td>8161.77 (3866.82)*</td>
<td>20 (48.8)</td>
<td>43</td>
<td>4500 (0)</td>
</tr>
<tr>
<td>3</td>
<td>41</td>
<td>8119.42 (3531.11)*</td>
<td>17 (41.5)</td>
<td>39</td>
<td>5000 (0)</td>
</tr>
<tr>
<td>4</td>
<td>39</td>
<td>8305.82 (3729.89)*</td>
<td>22 (56.4)</td>
<td>38</td>
<td>5500 (0)</td>
</tr>
<tr>
<td>5</td>
<td>40</td>
<td>8456.59 (3263.15)*</td>
<td>16 (40.0)</td>
<td>39</td>
<td>6000 (0)</td>
</tr>
<tr>
<td>6</td>
<td>40</td>
<td>8318.05 (3226.08)*</td>
<td>17 (42.5)</td>
<td>39</td>
<td>6500 (0)</td>
</tr>
<tr>
<td>7</td>
<td>37</td>
<td>8515.61 (3939.70)*</td>
<td>9 (24.3)</td>
<td>39</td>
<td>7000 (0)</td>
</tr>
<tr>
<td>8</td>
<td>38</td>
<td>8341.39 (4148.41)</td>
<td>18 (47.4)</td>
<td>37</td>
<td>7500 (0)</td>
</tr>
<tr>
<td>9</td>
<td>38</td>
<td>8048.13 (3412.30)</td>
<td>16 (42.1)</td>
<td>37</td>
<td>8000 (0)</td>
</tr>
<tr>
<td>10</td>
<td>39</td>
<td>8032.48 (3623.36)</td>
<td>17 (43.6)</td>
<td>34</td>
<td>8500 (0)</td>
</tr>
<tr>
<td>11</td>
<td>38</td>
<td>7709.24 (3517.78)*</td>
<td>16 (42.1)</td>
<td>34</td>
<td>9000 (0)</td>
</tr>
<tr>
<td>12</td>
<td>35</td>
<td>7510.57 (3546.73)*</td>
<td>34 (97.1)</td>
<td>34</td>
<td>9500 (0)</td>
</tr>
</tbody>
</table>

*Tailored (Intervention) step goal was significantly different from the targeted (Comparison) step goal, p<0.05.

<sup>a</sup> Number of participants may vary slightly from retention rates as all data was included and tailored goals were set only if Fitbit was synced in previous week.
CHAPTER VI: MEDIATION

VI. A. Overview

Self-determination theory, specifically constructs of autonomous motivation and perceived competence, has demonstrated a strong predictive relationship with changes in physical activity. However, few investigations have evaluated the role of these constructs on change in physical activity behavior in a web-based intervention. Thus, we aimed to evaluate the independent mediational relationship between change in autonomous motivation, as well as perceived competence, and change in physical activity in a solely web-based physical activity intervention.

Ninety inactive breast cancer survivors were enrolled in a 12-week web-based physical activity intervention. Participants were randomized to either weekly tailored emails (intervention), or weekly targeted emails (comparison). Behavioral constructs were assessed by standard self-determination questionnaires. Physical activity was assessed by a Fitbit Zip (step activity) and also by self-report (Mild, MVPA, total activity). Descriptive analyses were used to report motivation (autonomy, introjected, and external), self-efficacy (perceived competence and task self-efficacy), and goal-setting behavior at baseline, midpoint and follow-up. Mediation analyses evaluated change in autonomous motivation and perceived competence on change in steps at midpoint, and change in self-reported minutes of activity at one-week follow-up. Post-
hoc, moderation analyses evaluated the role of baseline autonomous motivation, as well as external (controlled) motivation, on change in steps at 12 weeks.

Significant decreases in introjected regulation were observed between baseline and follow-up for the intervention group (p= 0.02), but this difference was not significant from the comparison group (p= 0.52). Neither autonomous motivation nor perceived competence mediated change in steps and/or minutes of activity. Among participants with low autonomous motivation, targeted emails resulted in a greater positive change in steps, whereas, among participants with high autonomous motivation, tailored emails resulted in more positive change in steps. Finally, among participants with low controlled motivation, tailored emails resulted in a greater positive change in steps than targeted emails. No clinically meaningful differences were observed for participants with high controlled motivation.

Changes in objective step activity and self-reported minutes of activity following a 12-week web-based intervention were not mediated by change in autonomous motivation and perceived competence. While trends suggest that tailored emails produce a greater positive change in objective step activity among autonomous individuals, further research is needed with larger sample sizes to further investigate this association.
VI. B. Introduction

In 2013, an estimated 297,000 women were newly diagnosed with breast cancer (3, 124). Such a diagnosis can be life-changing for those diagnosed; however, with ever-improving medical treatment, the number of breast cancer survivors living five years beyond their initial diagnosis continues to grow (3). Research has demonstrated that engagement in regular physical activity can help maintain quality of life post-treatment and reduce incidence of early mortality and secondary cancers. As such, national physical activity guidelines recommend that breast cancer survivors engage at least 150 minutes of moderate-to-vigorous activity per week in addition to flexibility and strength training (94). However, despite these recommendations, the majority of breast cancer survivors remain inactive following treatment (3).

Efforts to understand not only the challenges that breast cancer survivors face in meeting physical activity recommendations, but also the best strategies to facilitate behavior change have been conducted (125, 126). A large meta-analysis by Webb and colleagues (49) demonstrated that web-based interventions grounded in behavioral theory were more effective than those that were not. Furthermore, they found that inclusion of determinants from multiple theories resulted in better behavioral outcomes, and provided greater insight about the mechanisms leading to behavior change.

In recent years, the Self-Determination Theory (SDT) has emerged as a promising theoretical framework for promoting motivation and self-actualization in the context of physical activity. Through this theory, key determinants of autonomy, relatedness and perceived competence are theorized to predict physical activity motivations (autonomous vs. controlled regulations) (66). Evaluation of the relationship between SDT and physical activity among adults has demonstrated consistent positive support for autonomous regulation and perceived
competence in predicting physical activity behavior (8). Furthermore, similar findings have also been observed in cross-sectional studies engaging breast and colorectal cancer survivors. In one such study, 220 older cancer survivors completed a cross-sectional survey evaluating predictors of activity (127). The study found that autonomous regulation was modestly associated self-reported minutes of moderate to vigorous activity (MVPA), and that there were no significant differences in outcomes between cancer and non-cancer cohorts.

A second promising behavior theory for engaging in physical activity is the Social Cognitive Theory (SCT) (41). This theory posits that positive behavioral change is grounded in the dynamic interplay between personal, behavioral and environmental factors. While there are a number of determinants and strategies within SCT, a meta-analysis conducted by Michie and colleagues (48) suggested that self-monitoring, in addition to one other behavioral strategy, such as goal-setting, may have significant additional benefit in successful behavior change. Much like the constructs within self-determination theory, SCT also recognizes the important role of self-efficacy in adopting and maintaining behavior (128), and in more recent years, the role of task self-efficacy (confidence in engaging in a specific behavior) in physical activity adoption (55).

Using the self-determination and social cognitive theories as guides, we previously determined the feasibility of implementing a tailored, internet-based, 12 week randomized trial to engage inactive breast cancer survivors in more weekly activity (as measured by change in average daily steps (per week) from baseline to follow-up). Our study specifically focused on developing autonomous motivation as well as building perceived competence, through weekly tailored emails which provided positive reinforcement, tailored step goal feedback, tailored weekly activity goals, encouraged choice, and promoted personal control. Primary outcomes from this study have been reported elsewhere (see chapter V), but in brief, we found that
participants randomized to receive the weekly tailored emails engaged in moderately more weekly steps and achieved their activity goals more often when compared to participants randomized to receive the weekly targeted emails.

As part of the randomized trial, we explored how changes in autonomous regulation and perceived competence mediated the change in objective step activity from baseline to the intervention midpoint. We hypothesized that participants exposed to the weekly tailored emails would exhibit greater change in autonomy and perceived competence between baseline and midpoint than participants exposed to the weekly targeted emails, thus resulting in a greater positive change in objective steps. Similarly, we also determined how changes in autonomous regulation and perceived competence mediated change in self-reported activity between baseline and follow-up. Specific self-reported activity outcomes included minutes of MVPA, mild, and total activity, as well as screen and sitting time. We hypothesized that participants exposed to the tailored emails would exhibit a greater change in autonomy and perceived competence between baseline and follow-up, resulting in a greater change in self-reported activity between baseline and follow-up. These results are reported below.

VI. C. Methods

Participants and Setting

A more detailed description of the study has been published elsewhere (see chapter V). In brief, the study was a two-arm, block randomized trial which took place between July 2013 and March 2014. Ninety inactive, post-treatment breast cancer survivors were recruited for a web-based study which aimed to increase average daily steps for each week of the study. Eligibility criteria included being: a) active for less than 30 minutes, 3 days per week (Stanford Brief
Activity Survey (99, 100)), b) 40-70 years of age, c) female with a self-reported history of breast cancer ≤stage II, d) 2-10 years post treatment completion (hormonal treatment okay), e) free from secondary cancers, f) fluent in English, g) able to ambulate without assistance, h) not concurrently enrolled in another physical activity/ weight loss program, i) without concurrent medical conditions precluding participants from engaging in regular activity (PAR-Q (101)) and, j) able to regularly access the internet/computer and an email account. The study protocol was approved by the Institutional Review Board at the University of North Carolina.

Study description

Study participants were randomized to receive 12 weekly emails which were either tailored or targeted based on random group assignment. Intervention emails were tailored, in the context of breast cancer survivorship, on weekly step achievement and self-reported barriers at baseline. Tailored weekly feedback was framed in such a way as to build participant autonomy and perceived competence (e.g., promotion of choice and control, positive reinforcement, proximal goal-setting, etc.). In contrast, weekly comparison group emails and feedback were not tailored, but rather framed in the context of breast cancer survivorship only. Weekly email topics included: rationale for increasing activity, overcoming barriers, setting meaningful goals, enjoying activity, reducing sedentary time, variety in exercise, and eating well for exercise.

Measures

Participants were asked to complete online questionnaires at baseline, study midpoint, and one-week follow-up, as well as wear a commercial accelerometer daily over the course of the intervention.
**Demographics:** Demographic information collected assessed participant age, race, marital status, education, income, employment status, and self-reported height and weight. Medical history included self-reported stage of breast cancer at diagnosis, age of diagnosis, cancer treatment history (radiation, chemotherapy, surgery), and use of aromatase inhibitors.

**Physical activity:** All participants were provided with a commercial accelerometer, the Fitbit Zip (Fitbit Inc., San Francisco), to objectively monitor average weekly step activity. Participants were instructed to wear their Fitbit daily and sync it at least every 3-4 days. Self-reported activity was evaluated using the Godin Leisure Time Exercise Questionnaire (GLTEQ) (109). The GLTEQ is a four-item measure that evaluates mild activity (minimal effort, e.g., yoga, easy walking), moderate activity (e.g., fast walking, easy swimming/cycling), and strenuous activity (e.g., running, jogging) as completed in the last seven days. In order to calculate minutes of activity, we modified the GLTEQ to include three additional questions pertaining to minutes spent in each activity (mild, moderate and strenuous) (110). We also evaluated sedentary behavior using a single question on sitting time (*During the last 7 days, how much time did you usually spend sitting?*) (82), and a single question on television/screen viewing time (*Over the past 30 days, in your leisure time, how many hours per day, on average, did you sit and watch TV or movies, surf the web, or play computer games?*) (111).

**Motivation:** The Treatment Self-Regulation Questionnaire for exercise (106, 129) was used to evaluate motivation. This 15-item scale specifically evaluates participant self-determination ranging from autonomy (self-determined behavior that is not driven by external influences), introjected regulation (behavior to avoid feelings of guilt), external regulation (behavior for external rewards), to amotivation (lack of motivation to engage in behavior).
items were evaluated on a scale from Not at all True (1) to Very True (7), and scores for each sub-category were averaged (130).

**Perceived Competence:** The Perceived Competence Scale (129, 131) was used to evaluate confidence and mastery related to physical activity. Four questions asked if participants felt confident, capable, and able to exercise regularly. Each of the four items in the questionnaire was assessed on a scale of 1-7, ranging from: Not at all True (1) to Very True (7), and were averaged to achieve a composite score.

**Task Self-Efficacy:** Task Self-Efficacy for physical activity was evaluated using a 4-item scale developed specifically for breast cancer patients (55, 132). Specific questions included asking participants to rate their confidence from Not at all Confident (1) to Extremely Confident (5) for the following items: walking briskly for 20 minutes without stopping, running or jogging for 10 minutes without stopping, climbing three flights of stairs without stopping, and exercising for 20 minutes at a level hard enough to cause increases in heart rate and breathing. Scores for each sub-category were then averaged to achieve a composite score.

**Goal Setting:** Finally, the Exercise Goal Setting Scale (133) evaluated goal-development (e.g., I usually set goals), self-monitoring (e.g., I usually keep track of my progress in meeting my goals), and problem-solving (e.g., If I do not reach an exercise goal, I analyze what went wrong) as related to physical activity. Responses for this 10-item scale ranged from: Does not Describe Me (1) to Completely Describes Me (5) and were average for an overall score.

**Statistical Analyses**

All data analyses were conducted using SAS statistical software (version 9.3, Cary, NC). Sample size for the primary outcome (change in average daily steps (by week) between baseline
and follow-up) was calculated using a two-group independent t-test with 80% power, and alpha = 0.05 to detect a mean difference of 650 steps (SD=1000) between groups. The sample size was calculated to be 78 participants. Accounting for a 15% attrition rate, we aimed to recruit 90 participants (45 per group).

Mixed method analyses were used to evaluate unadjusted mean changes in autonomy, introjected regulation, external regulation, perceived competence, task self-efficacy, and goal-setting between baseline and study midpoint, as well as between baseline and follow-up. We report descriptive values at each time point (baseline, midpoint, follow-up), as well as the average mean change, 95% confidence interval, and significance for within and between group change.

To evaluate how changes in autonomy and perceived competence mediated both objective step activity and self-reported activity, we employed Zhao’s mediational step analysis (134). We chose this approach based on its improvement over the traditional Baron and Kenny (135) approach which rules out any mediation if the total effect is not significant. Zhao’s approach posits that mediation is present if the indirect effect is significant regardless of the total effect. For this study, simple regressions were run in order to estimate if autonomy and perceived competence mediated the relationship between exposure to the intervention and objective step activity and self-reported activity. Separate models were used to avoid issues of collinearity.

The general model used to test mediation for each of the proposed mediators (autonomy, perceived competence) and activity outcomes (change in steps, and self-reported activity) were as follows: 1. Regress the change in activity over time on the intervention variable (total effect of the intervention on activity); 2. Regress the change in mediators on the independent variable (intervention group); 3. Regress the change in activity on group controlling for the mediators,
and; 4. Conduct Sobel test to test the significance of the indirect effect. For analyses, a p-value of <0.05 was considered statistically significant.

VI. D. Results

Baseline demographic information has been reported previously (see Chapter V, Supplemental Table 5.1). Briefly, breast cancer survivors were an average age of 55.03 (±7.31) years, and predominantly white (97.7%). Most participants were college-educated (64.5%), and reported an annual household income above $50,000 (82.5%). On average, participants were 4.3 (2.05) years post treatment completion, and most considered their baseline health to be good to very good (85.6%). There were no significant differences in baseline characteristics between groups, although there was a trend toward significance for age (p= 0.056). There were also no differences in baseline steps (n=39 per group; p=0.34), or self-reported baseline activity (n=40 per group; p= 0.23), between groups.

Descriptive Changes in Theoretical Determinants

Baseline and intervention midpoint: From baseline to intervention midpoint (Table 6.1), there was a significant decrease in perceived competence between baseline and intervention midpoint (p=0.005) for the tailored group, but this change was not significantly different from the target group (p=0.38). The tailored group also engaged in significantly more goal-setting behaviors (p= 0.01), but again this was not significantly different from the target group. Finally, there was a trend toward significance in the tailored group for introjected regulation (p= 0.078), but again this was not significantly different from the target group (p=0.46). Additionally, no
significant trends were observed for autonomy, external regulation, and task self-efficacy between baseline and intervention midpoint within or between groups.

*Baseline and one-week follow-up:* From baseline to follow-up (Table 6.2), we observed a significant decrease in introjected regulation over time (p= 0.02) in the tailored group, but this decrease was not significantly different to the target group (p= 0.52). Similar significant changes were observed for task self-efficacy and goal-setting for both groups over time. However, there were no significant differences between groups for either task self-efficacy (p= 0.84) or goal-setting (p= 0.38). No other significant trends were observed for autonomy, external regulation, or perceived competence between baseline and follow-up.

*Mediation: Change in Steps between Baseline and Midpoint*

The total effect of the intervention on changes in steps between baseline and intervention midpoint was non-significant (b=621.4; SE=648.8, p=0.341). Similarly, the effect of the intervention on change in steps when controlling for autonomy remained non-significant (b=615.9; SE=651.1, p=0.347). Indirect models confirmed that autonomy did not mediate observed changes in average steps (b=5.42; SE=55.89, p=0.92).

Similar mediational outcomes were observed for perceived competence. The effect of the intervention on change in steps when controlling for perceived competence was non-significant (b=840.7; SE=615.9, p=0.18). Indirect models confirmed that mediation was not present for perceived competence (b= -219.3; SE=237.7, p=0.36) (Supplemental Table 6.1).
Mediation: Change in Self-reported Activity between Baseline and Follow-up

Supplemental Table 6.2 in the Appendix depicts mediational outcomes for autonomy and self-reported minutes of activity between baseline and follow-up. Mediational models for autonomy were non-significant for moderate to vigorous activity (b=-0.88; SE=6.15, p=0.886), mild minutes (b=-0.41; SE=2.85, p=0.886), total minutes (b=-1.29; SE=8.97, p=0.886), sitting time (b=0; SE=0, p=0.929), and screen time (b=0.01; SE=0.05, p=0.886).

Similar non-significant effects were observed for perceived competence and self-reported minutes of activity between baseline and follow-up (Supplemental Table 6.2 in Appendix). Mediational models for perceived competence were non-significant for moderate to vigorous activity (b=1.52; SE=10.34, p=0.883), mild minutes (b=0.64; SE=4.39, p=0.883), total minutes (b=2.17; SE=14.71, p=0.883), sitting time (b=0; SE=0.01, p=0.892), and screen time (b= -0.01; SE=0.04, p=0.884).

Moderation of Autonomous and External Regulation as a Predictor of Step Activity at 12 weeks

In post-hoc analyses, we explored potential correlations and moderating effects of autonomous and controlled regulation. Pearson correlations revealed that autonomous and controlled regulation were not significantly correlated with change in steps at 12 weeks (p=0.51 and p=0.41, respectively). In moderation analyses, we observed that participants in the target group who were low on autonomous regulation (-1SD) walked about 560 steps more than participants in the target group who were high (+1SD) on autonomous regulation (p=0.63). However, participants in the tailored group who were high on autonomous regulation, walked about 600 steps more than participants in the tailored group who were low on autonomous regulation (p=0.53) (Fig. 6.1).
Furthermore, participants in the target who were classified as low (-1SD) on external regulation took slightly more steps than target participants who were classified as high (+1SD) on external regulation, but again, this difference was not significant (p=0.89). Among tailored participants classified as low on external regulation took about 730 more steps than tailored participants who were classified as high on external regulation (p=0.43) (Fig. 6.2).

VI. E. Discussion

The primary purpose of this study was to evaluate if change in autonomy and perceived competence mediated the relationship between intervention exposure and change in objective and self-reported activity outcomes. Change in objective steps from baseline to intervention midpoint was measured using the Fitbit Zip, and change in self-reported activity was measured using online questionnaires at baseline and follow-up.

Mediational Outcomes

Our study found that autonomy and perceived competence did not mediate changes in objective step activity between baseline and intervention midpoint. Furthermore, we found that these determinants also did not mediate change in self-reported minutes of MVPA, mild physical activity, and total physical activity, nor did it mediate change in self-reported hours of sitting and screen time between baseline and follow-up.

The lack of an effect in our proposed mediational models was unexpected given the current support for autonomous regulation as a predictor of activity in both observational and experimental studies (68). To better understand our findings, we identified those experimental studies in the literature which assessed the role of autonomous regulation (as measured by the TSRQ) to increase physical activity. We ultimately identified two such trials (136, 137).
In the first trial (136), 120 participants were randomized to receive either brief autonomy supportive counseling or, in addition to the brief counseling, autonomy supportive physical activity counseling over three months. Counseling was delivered via face-to-face and telephone-based communications. In the second, 4-week, study (137), 176 cardiac rehabilitation participants were randomized to receive either standard of care (daily exercise training), or in addition to exercise training, face-to-face or telephone-based counseling. The first study ultimately demonstrated significant changes in autonomous regulation, while the second study had null results. While these studies did not provide obvious insights about our lack of findings, it is possible that mode of intervention delivery or length of study may have played a role in these finding. Future studies are needed to explore these hypotheses further.

While there is some evidence stating that there are no significant differences in studies delivered via web-based approaches (49, 138), there is growing debate about the appropriate use of traditional behavioral theories in more technologically-driven behavioral interventions. In a meta-analysis and systematic review of internet-based behavioral change programs, Webb and colleagues suggest that merging multiple theories, as well as focusing on engagement strategies, might have improved behavioral outcomes (49). However, future studies should evaluate the appropriate use, as well as efficacy, of a web-based trial grounded in the self-determination theory.

Finally, it is also possible that the lack of a mediation effect for both autonomy and perceived competence may be a result of a ceiling effect. At all data collection time points, we found that most participants rated their autonomy and perceived competence favorably (5-7 points on average), leaving little room for improvement. Thus, in post-hoc analyses, we chose to explore if a moderation effect was present. We chose to evaluate only autonomous and
controlled regulation based on a study by Webber and colleagues (139) which demonstrated that behavioral outcomes varied by these baseline motivations.

Our moderation analyses demonstrated that for participants with low autonomy, a targeted intervention was more effective, and similarly, among participants with high autonomy, a tailored intervention was more effective. There were no apparent differences among those participants in the target group for controlled regulation, but among participants in the tailored group, those participants with low controlled regulation did better than those participants in the tailored group with high controlled regulation. However, future studies with larger sample sizes are needed to truly assess if the effects observed are significant.

Changes in Theoretical Determinants

While not hypothesized, we observed significant mean changes in other theoretical determinants for self-reported activity. First, we observed changes in introjected regulation at intervention follow-up. Introjected regulation is a form of controlled motivation, but serves as the bridge between autonomous and controlled behaviors. Our study found that while there were no significant changes between groups at intervention midpoint and follow-up, participants in the tailored group significantly decreased introjected regulation over time, whereas participants in the target group regressed towards their baseline values over time. This is particularly interesting in light of the null results for autonomous regulation and may suggest that while there was movement away from external regulation for both groups, the tailored group ultimately reached and maintained a significant change from baseline.

Secondly, while we did not observe hypothesized changes in perceived competence, we did observe significant positive changes in task-self-efficacy at one-week follow-up. The distinction between perceived competence and task self-efficacy is important. Perceived
competence, in the context of SDT, evaluates perceptions of being able to engage in regular activity, whereas task self-efficacy, in the context of SCT, evaluates how confident an individual is to engage in a specific physical activity task. Thus, the significant findings for task self-efficacy align well with the behavioral intervention literature (55) especially in light of the provision of accelerometers to monitor and track activity.

We also observed changes in goal-setting behavior in both groups over time. At the study midpoint, tailored participants reported significant increases in goal-setting behaviors from baseline, and at one-week follow-up, both the tailored and targeted groups had significant increases in goal-setting behaviors. These findings were not unexpected especially in light of the weekly emails which asked participants to set step goals, and thus may reflect increased compliance with weekly goal setting.

**Strengths and Limitations**

Finally, our findings should be understood in the context of our study’s strengths and limitations. First, our study was limited to observing change in objective steps between baseline and intervention midpoint. This decision was made due to the high non-compliance rates observed at one-week follow-up, where approximately 57 percent of participants had complete objective data. However, self-reported data (as collected by baseline and follow-up questionnaires), had good completion rates (89%) and thus mediation models for self-reported data were calculated using data at one-week follow-up.

Second, our study was powered to evaluate changes in our primary outcome, objective weekly steps, rather than changes in autonomy and perceived competence. Thus, it is possible that the lack of mediation effects is a result of lack of power.
Beyond our study limitations, there are number of strengths. First the randomized control design allowed us to evaluate relationships in a causal manner. In addition, we had stronger than typical retention rates from baseline to follow up for self-reported outcomes which enabled us to evaluate mediators more robustly. Lastly, our study is one of the first to evaluate a web-delivered intervention testing self-determination theory constructs in the context of an inactive breast cancer survivor population. And while our study did not confirm our hypothesized mediators, we did note a potential moderating role of autonomy and external motivation on change in steps.

Thus, our study findings lay the groundwork for future studies to explore and expand on the role of the self-determination theory, specifically the evaluation of autonomy and external motivation as moderators. Furthermore, because we observed that introjected regulation was more susceptible to change than external motivation, future studies might explore in larger samples, over a longer time period, the relationship between introjected regulation and changes in physical activity.
Table 6.1 Change in determinants between baseline and midpoint

<table>
<thead>
<tr>
<th>Outcome</th>
<th>BL</th>
<th>Midpoint</th>
<th>Modeled Uandj. Mean Change (W1-W6) Mean (95% CI)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autonomy</td>
<td></td>
<td></td>
<td></td>
<td>0.9249</td>
</tr>
<tr>
<td>Tailored</td>
<td>6.21 (0.74)</td>
<td>6.31 (0.69)</td>
<td>0.07 (-0.15, 0.30)</td>
<td></td>
</tr>
<tr>
<td>Targeted</td>
<td>6.32 (0.77)</td>
<td>6.44 (0.68)</td>
<td>0.06 (-0.17, 0.29)</td>
<td></td>
</tr>
<tr>
<td>Introjected Regulation</td>
<td></td>
<td></td>
<td></td>
<td>0.4631</td>
</tr>
<tr>
<td>Tailored</td>
<td>4.57 (1.53)</td>
<td>4.03 (2.11)</td>
<td>-0.49 (-1.03, 0.06)</td>
<td></td>
</tr>
<tr>
<td>Targeted</td>
<td>3.87 (1.72)</td>
<td>3.63 (1.77)</td>
<td>-0.20 (-0.75, 0.34)</td>
<td></td>
</tr>
<tr>
<td>External Regulation</td>
<td></td>
<td></td>
<td></td>
<td>0.5477</td>
</tr>
<tr>
<td>Tailored</td>
<td>2.48 (1.34)</td>
<td>2.31 (1.35)</td>
<td>-0.14 (-0.49, 0.21)</td>
<td></td>
</tr>
<tr>
<td>Targeted</td>
<td>2.57 (1.32)</td>
<td>2.12 (1.17)</td>
<td>-0.29 (-0.64, 0.06)</td>
<td></td>
</tr>
<tr>
<td>Perceived Competence</td>
<td></td>
<td></td>
<td></td>
<td>0.3800</td>
</tr>
<tr>
<td>Tailored</td>
<td>5.51 (1.30)</td>
<td>4.81 (1.51)</td>
<td>-0.72 (-1.21, -0.22)**</td>
<td></td>
</tr>
<tr>
<td>Targeted</td>
<td>5.90 (1.07)</td>
<td>5.51 (1.44)</td>
<td>-0.41 (-0.90, 0.09)</td>
<td></td>
</tr>
<tr>
<td>Task Self Efficacy</td>
<td></td>
<td></td>
<td></td>
<td>0.9269</td>
</tr>
<tr>
<td>Tailored</td>
<td>3.36 (0.75)</td>
<td>3.52 (0.85)</td>
<td>0.17 (-0.07, 0.40)</td>
<td></td>
</tr>
<tr>
<td>Targeted</td>
<td>3.69 (0.74)</td>
<td>3.89 (0.80)</td>
<td>0.18 (-0.05, 0.41)</td>
<td></td>
</tr>
<tr>
<td>Goal Setting</td>
<td></td>
<td></td>
<td></td>
<td>0.2588</td>
</tr>
<tr>
<td>Tailored</td>
<td>1.95 (0.83)</td>
<td>2.31 (0.89)</td>
<td>0.37 (0.08, 0.66)**</td>
<td></td>
</tr>
<tr>
<td>Targeted</td>
<td>2.20 (0.96)</td>
<td>2.34 (0.96)</td>
<td>0.14 (-0.16, 0.43)</td>
<td></td>
</tr>
</tbody>
</table>

Note: Tailored (intervention group), Targeted (comparison group)  *= p<0.0001, **= p<0.05
Table 6.2 Change in determinants between baseline and follow-up.

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Baseline</th>
<th>Follow-up</th>
<th>Modeled Uandj. Mean Change (W1-W12)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mean (95% CI)</td>
<td></td>
</tr>
<tr>
<td>Autonomy</td>
<td>6.21 (0.74)</td>
<td>6.22 (0.87)</td>
<td>-0.01 (-0.25,0.24)</td>
<td>0.6483</td>
</tr>
<tr>
<td>Tailored</td>
<td>6.32 (0.77)</td>
<td>6.46 (0.75)</td>
<td>0.07 (-0.17,0.32)</td>
<td></td>
</tr>
<tr>
<td>Targeted</td>
<td>6.32 (0.77)</td>
<td>6.46 (0.75)</td>
<td>0.07 (-0.17,0.32)</td>
<td></td>
</tr>
<tr>
<td>Introjected Regulation</td>
<td>4.57 (1.53)</td>
<td>3.85 (1.90)</td>
<td>-0.65 (-1.20,-0.10)**</td>
<td>0.5252</td>
</tr>
<tr>
<td>Tailored</td>
<td>3.87 (1.72)</td>
<td>3.45 (1.97)</td>
<td>-0.40 (-0.95,0.15)</td>
<td></td>
</tr>
<tr>
<td>Targeted</td>
<td>3.87 (1.72)</td>
<td>3.45 (1.97)</td>
<td>-0.40 (-0.95,0.15)</td>
<td></td>
</tr>
<tr>
<td>External Regulation</td>
<td>2.48 (1.34)</td>
<td>2.28 (1.19)</td>
<td>-0.18 (-0.52,0.15)</td>
<td>0.7267</td>
</tr>
<tr>
<td>Tailored</td>
<td>2.57 (1.32)</td>
<td>2.19 (1.37)</td>
<td>-0.27 (-0.60,0.06)</td>
<td></td>
</tr>
<tr>
<td>Targeted</td>
<td>2.57 (1.32)</td>
<td>2.19 (1.37)</td>
<td>-0.27 (-0.60,0.06)</td>
<td></td>
</tr>
<tr>
<td>Perceived Competence</td>
<td>5.51 (1.30)</td>
<td>5.39 (1.44)</td>
<td>-0.13 (-0.59,0.34)</td>
<td>0.9474</td>
</tr>
<tr>
<td>Tailored</td>
<td>5.90 (1.07)</td>
<td>5.76 (1.25)</td>
<td>-0.15 (-0.61,0.31)</td>
<td></td>
</tr>
<tr>
<td>Targeted</td>
<td>5.90 (1.07)</td>
<td>5.76 (1.25)</td>
<td>-0.15 (-0.61,0.31)</td>
<td></td>
</tr>
<tr>
<td>Task Self Efficacy</td>
<td>3.36 (0.75)</td>
<td>3.75 (0.81)</td>
<td>0.41 (0.19,0.64)*</td>
<td>0.8454</td>
</tr>
<tr>
<td>Tailored</td>
<td>3.69 (0.74)</td>
<td>4.07 (0.71)</td>
<td>0.38 (0.15,0.61)**</td>
<td></td>
</tr>
<tr>
<td>Targeted</td>
<td>3.69 (0.74)</td>
<td>4.07 (0.71)</td>
<td>0.38 (0.15,0.61)**</td>
<td></td>
</tr>
<tr>
<td>Goal Setting</td>
<td>1.95 (0.83)</td>
<td>2.47 (0.96)</td>
<td>0.52 (0.24,0.81)*</td>
<td>0.3767</td>
</tr>
<tr>
<td>Tailored</td>
<td>2.20 (0.96)</td>
<td>2.54 (0.97)</td>
<td>0.35 (0.06,0.63)**</td>
<td></td>
</tr>
<tr>
<td>Targeted</td>
<td>2.20 (0.96)</td>
<td>2.54 (0.97)</td>
<td>0.35 (0.06,0.63)**</td>
<td></td>
</tr>
</tbody>
</table>

Note: Tailored (intervention group), Targeted (comparison group) * = p<0.0001, ** = p<0.05
Figure 6.1 Autonomous regulation and associated change in steps.

Figure 6.2 Controlled regulation and associated change in steps.
CHAPTER VII: SUMMARY AND RECOMMENDATIONS

Summary

The aim of this dissertation was to evaluate the feasibility of delivering a web-based, tailored intervention to promote physical activity among a group of inactive post-treatment breast cancer survivors. Major findings of this dissertation were as follows:

1) The Fitbit Zip is a valid commercial accelerometer for measuring real-time step activity among free-living adults, and may be easily integrated into a web-based intervention among post-treatment breast cancer survivors. Given that additional research is needed to evaluate Fitbit’s classification of sedentary time versus non-wear time, as well as Fitbit’s classification of physical activity intensity (lightly active, fairly active and very active activity), the Fitbit Zip may serve better as a health promotion tool until a more well-defined activity algorithm is developed.

2) A web-based, tailored intervention is a feasible, acceptable, and efficacious route for significantly increasing attainment of step goals, achieving moderate changes in step activity, as well as significantly reducing self-reported screen time.

3) Neither autonomous motivation nor perceived competence significantly mediated changes in physical activity between the tailored and targeted message groups over time.
Thus, the results of this dissertation suggest that a web-based, tailored intervention is a feasible way to not only recruit and reach breast cancer survivors, but also promote behavior change among those survivors wishing to engage in more regular physical activity.

As medical treatments for women diagnosed with breast cancer continue to improve, similar positive trends in years lived beyond diagnosis begin to grow. While these are welcomed trends and changes in survivorship, concern remains about the quality of life for breast cancer survivors following treatment. Specifically, there are a multitude of physical and psychosocial side effects which may persist long after treatment completion such as fatigue, pain, fear of recurrence, and even shame. Behavioral change interventions have demonstrated that regular physical activity can mitigate many of the lingering side effects of treatment, but few breast cancer survivors engage in regular activity, let alone meet national physical activity guidelines.

With the increased interest of web- and mobile-based behavioral programs, self-directed interventions hold promise as a way to not only incorporate such technology, but also reach a greater number of breast cancer survivors than more traditional, supervised, interventions. Furthermore, technology-based programs lend themselves more easily to tailoring, another highly successful approach often used in behavior change interventions. However, to date, it is unknown if a tailored message approach leads to greater step achievement among inactive breast cancer survivors than a targeted message approach.

Thus, this dissertation aimed to address this gap in the literature while contributing important insights about the delivery of such an intervention among post-treatment breast cancer survivors. The following sections summarize the results of each aim, and explore the implications of the findings.
Aim 1

In the first aim, reported in Chapter IV, we conducted a validation study of the Fitbit Zip, a commercial accelerometer, in a group of 35 free-living, healthy adults. Study participants were asked to wear two accelerometers (Fitbit Zip and ActiGraph GT3X), during all waking hours over a 24-hour period. Activity data collected from participants were used to compare and contrast the Fitbit Zip and the ActiGraph GT3X for the following activity outcomes: steps taken, sedentary minutes, and minutes of research-defined mild, moderate and very active activity. Because the algorithms to define Fitbit activity (Lightly Active, Fairly Active, and Very Active) are not publicly available, we also sought to explore how these activity categories were defined using research-based activity cut-points.

Results from Aim 1 indicated that steps recorded by the Fitbit Zip had a strong linear relationship with steps recorded by the ActiGraph. However, the Fitbit slightly overestimated steps counts; for step averages below 7,000 daily steps, the Fitbit overestimated steps by about four percent, whereas for step averages above 10,000 daily steps, the Fitbit overestimated steps by about 10%. Sedentary minutes were also strongly correlated, but this was only true once non-wear time was accounted for. Finally, Fitbit’s classification of Lightly Active, Fairly Active, and Very Active activity most closely matched with the published research cut-points for light and moderate activity.

To the best of our knowledge, our study is the first to validate the Fitbit Zip in a free-living population and evaluate Fitbit’s classification of activity intensity. Previous research has demonstrated in laboratory studies that the Fitbit is a valid and reliable instrument for measuring step activity, but not for assessing distance traveled. Our findings add to this body of research by
exploring the validity of the Fitbit in a free-living population, as well as by evaluating Fitbit’s
definition of *Lightly Active*, *Fairly Active*, and *Very Active* activity.

This study has implications for future research especially in light of this age of
technology. The Fitbit Zip not only provides a low-cost alternative to the traditional research
accelerometer, but also provides a myriad of opportunities to gain greater insights in intervention
research. To start, the Fitbit objectively tracks user activity in real-time. This has implications for
intervention research that focuses on momentary ecological assessment. For example, an
intervention study using a commercial accelerometer- like the Fitbit- may track a participant’s
immediate activity response to the type, or even number, of prompts received (e.g., a text
message, email, or telephone call). Additionally, use of the Fitbit Zip on a daily basis may give
researchers a better understanding about changes in objectively-measured activity over time. For
example, researchers may use the Fitbit to track changes in activity of breast cancer survivors
from the moment of diagnosis to well after treatment. Furthermore, the Fitbit also allows the
researcher to track various dimensions of activity at the same time—tracking of steps taken, as
well as intensity and length of activity—which allows for a more holistic interpretation of a
participant’s activity level. However, as indicated earlier, the Fitbit is limited in interpreting
research-defined very active intensities, as well as differentiating between non-wear and
sedentary time. And thus, the Fitbit may serve better as a health promotion tool until such time
more strongly defined algorithms for physical activity intensity are incorporated.

**Aim 2**

In our second aim, found in Chapter V, we evaluated and compared the feasibility and
efficacy of a 12-week low-intensity, web-based, tailored intervention to a similar 12-week
intervention that was not tailored. While few interventions have compared tailored versus targeted messages, this study was one of the first to have tested web-based delivery of tailored messages among breast cancer survivors recruited from across the United States. Furthermore, to the best of our knowledge, this is the first study to evaluate the feasibility and efficacy of tailoring weekly activity goals and feedback based on real-time objective data collection. Finally, this study is one of the first to explore the feasibility of incorporating a validated commercial activity tracker to monitor and evaluate participant activity over the course of the intervention.

As hypothesized, we demonstrated the feasibility of recruiting and retaining post-treatment breast cancer survivors to participate in a 12-week web-based physical activity intervention. Over a four month recruitment period, we screened over 685 interested individuals, of whom 114 were eligible, and 90 who were ultimately consented and enrolled into the study. Despite efforts to recruit participants from minority organizations (e.g., via Sisters Network, word of mouth, community events), our study population was comprised of primarily white survivors. However, there was participant variability in terms of age of diagnosis, stage of initial diagnosis, type of treatment received, and time since treatment completion. Additionally, participants were recruited from geographically diverse locations, with the most successful recruitment taking place from North Carolina, California, Texas, and New York.

Over the course of the intervention, we had excellent retention rates for the self-reported questionnaires which were completed at baseline, midpoint (87%), and at one-week follow-up (88%). We had similar, strong, retention rates for weekly Fitbit data collection (78%), with the exception of the follow-up week where we observed an unusual drop in the number of participants with valid data (57%). Given the excellent completion rates of the self-reported follow-up questionnaire, this drop in available Fitbit data was likely the result of a poorly worded
email that did not emphasize the need to wear and sync the Fitbit in the week following the intervention.

Despite this anomaly, our study still demonstrated that the majority of participants remained actively engaged over the course of the intervention. While we hypothesized that this continued engagement was a result of weekly prompts to set goals and monitor activity, future studies should explore how retention rates change following the end of such an intervention, especially in light of the usual downward trends in retention observed in non-interactive web-based studies (117, 140).

In Aim 2, we also found that our theory-based intervention, delivered via weekly tailored or targeted emails, produced the following results: 1) significant increases in goal achievement in the tailored message group during the last month of the study; 2) moderate effect sizes for change in steps between groups at study midpoint and follow-up; and 3) significant reductions in screen time between study groups over time. These findings were in line with previous behavioral intervention trials, as well as meta-analyses, that suggest that proximal goal-setting and self-monitoring are important tools in promoting behavior change.

While we did find significant outcomes for step goal achievement, it is important to understand these findings within the context of our study. Our study intervention group received weekly emails with tailored step goals that were based on the previous week’s step performance. This was in comparison to the target message group who received weekly emails with predefined step goals based on standard step progression programs. As a result, the target group’s step goals were innately “easier” to reach than the tailored group’s step goals at the beginning of the study. However, as targeted goals became progressively harder to reach, fewer and fewer target group participants achieved their weekly step goals. In contrast, as tailored step goals became
progressively harder, the number of tailored group participants achieving their step goals remained consistent for each week.

While this pattern of step achievement was not unexpected, we did not anticipate that there would be such little overlap of step goals between groups (only three weeks had step goals that were not significantly different between groups). To avoid this issue in future studies, consideration should be given to set the comparison group’s initial step goals based on their average baseline steps, and then progress goals systematically as proposed in our trial. Doing this would potentially allow for more step goal overlap between groups, and thus more meaningful interpretation of step goal achievement.

Finally, it is also important that future studies explore the careful line between setting a weekly goal that is customized, and setting one that presents an appropriate challenge. During the course of our study, we observed that some of the tailored group participants’ step goals plateaued early on in the study, and thus had step goals that remained fairly constant. Future studies should explore how to motivate these types of participants either by providing them with a choice to enter “temporary maintenance”, or to provide a smaller, yet still progressive, step goal. Additionally, the format of the web-based messages could be alternated so that each email’s message and/or format looks slightly different and potentially more intriguing. Thus, participants would likely remain interested and challenged, while remaining confident in their ability to maintain activity.

Aim 3

Our randomized intervention trial was guided by two behavioral theories: Social Cognitive Theory and Self-determination Theory. We hypothesized that determinants from these
theories would provide further insight into the mechanism behind behavioral changes observed in our intervention. Specifically, we sought to assess the role of autonomy and perceived competence (Self-determination Theory) given the strong support in the literature for their use in behavioral interventions, and hypothesized that changes in autonomy and perceived competence would mediate the relationship between exposure to the intervention and change in activity (objective steps, and self-reported activity).

However, our mediation analyses did result in the direction of our hypothesized changes. Instead we found, in simple mediation models, that neither change in autonomy nor perceived competence significantly mediated the relationship between exposure to the intervention and change in steps or self-reported activity.

Our mediation findings were unexpected given the positive results in other observational and experimental studies. In a systematic review of 66 studies, Teixeira and colleagues examined the relationship between self-determination and physical activity (68). The review included both observational and experimental studies and results demonstrated consistent positive support for the role of autonomous regulation in physical activity adoption.

To better understand our null findings, we examined the literature more closely. Among the experimental studies in Teixeira’s review, we noted that there was large variability in the types of measures used to evaluate autonomy and perceived competence. Only two experimental studies evaluated autonomy using the same measure used in our study (TSRQ for exercise) ((70, 137). Of these studies, only one demonstrated significant positive changes in autonomy (comparison between intervention and control groups) (70), while the other reported null findings (137). Thus, it is possible that the TSRQ did not capture autonomy as well as the other
measures might have, and so future studies should explore the use of alternative measures to evaluate autonomy and perceived competence.

We also noted that, much like our study, participants in Fortier’s (70) and Mildestvedt’s (137) studies had high baseline scores for autonomy and perceived competence, leaving little room for improvement (both scales measured from 1 (lowest) to 7 (highest)). This observation is of special relevance to the current study because it may actually suggest a lack of power.

However, despite these small non-significant changes, it is still important to point out that perceived competence decreased slightly in both groups over the course of the intervention. This finding was unexpected given the strong emphasis on developing behavioral competence through setting proximal behavioral goals, problem-solving behavioral barriers, and providing positive reinforcement and feedback. One explanation for our findings may be related to exposure to the intervention. Over the course of the study, participants likely developed a better understanding of their physical activity competence. Thus, it is possible that study participants were able to interpret the questions related to perceived competence with greater insight due to their recent experience, and thus responded more conservatively to perceived competence questions. This explanation appears to be supported by the positive changes in perceived competence from the study midpoint to one-week follow-up where scores returned to almost baseline values. At study midpoint, perceived competence was rated lower than at baseline for both the tailored and targeted groups, but at one-week follow-up, perceived competence was rated more favorably than at midpoint by both groups.

Finally, in post-hoc moderation analyses, we also observed modest changes in step activity between baseline and 12 weeks (although changes observed were not statistically significant) based on baseline motivation. Specifically, we observed that participants assigned to
the tailored group who had high autonomous motivation had a larger change in daily steps over the course of the intervention than those participants with high autonomous motivation who were assigned to the targeted group. Furthermore, those participants assigned to the tailored group who had low autonomous motivation had a smaller change in steps over the course of the intervention compared to those participants with low autonomous motivation assigned to the targeted group.

These post hoc moderation findings for autonomous motivation were not unexpected. The tailored intervention components used in the study were guided by determinants from self-determination theory, specifically autonomy and perceived competence. Self-determination theory posits that behavioral interventions that incorporate strategies to promote autonomous motivation lead to positive changes in behavior. Given that the tailored group’s weekly emails were developed in such a way to promote choice, provide positive feedback and reinforcement of behavior, and encourage problem-solving, it was not unexpected that those participants classified as high on autonomous motivation responded more favorably to the tailored emails over the course of the intervention than those participants classified as high on autonomous motivation and who were randomized to the targeted group.

We also observed notable trends in step activity between the tailored and targeted groups for those participants who were classified as either high or low on controlled (external) motivation. For those participants with low controlled (external) motivation, there did not appear to be a clinically meaningful difference in step activity over the course of the intervention regardless of their group assignment (tailored or targeted emails). Conversely, those participants who were high on controlled (external) motivation fared better if they were randomized to the targeted group than the tailored group.
Again, these post-hoc moderation observations for controlled (external) motivation were not unexpected. Because the tailored group’s emails were designed to promote autonomy, it is likely that these strategies were not an effective approach among those participants reporting high controlled motivation. The opposite trend in step activity was observed for participants in the targeted group where weekly emails did not incorporate strategies to build autonomy (or reduce controlled (external) motivations).

Thus the results of Aim 3, while not statistically significant, do suggest that this may be an important area for further research especially in light of the positive support in the literature. Our study, while seemingly underpowered, is one of the first to test the mediational effects of autonomy and perceived competence on change in physical activity in a web-based trial, and thus our results should be interpreted as exploratory analyses rather than definitive outcomes.

Future Directions and Research Needs

The following are recommendations for future research based on the findings from this dissertation:

1. In our intervention trial, the Fitbit served as both an intervention tool and validated primary outcome measure for steps taken. We found that the Fitbit was easy to integrate, and that most participants had little trouble using it. However, without the help of a computer programmer, access to the backend data may not have been possible. As such, researchers who might be considering using a commercial accelerometer should opt to choose a device that is accompanied not only by free website usage, but also gives
backend data access to the user. This will help reduce study-related costs and researcher-burden.

Furthermore, while we developed our study to include the Fitbit, the Fitbit was merely a proxy for a number of different types of self-monitoring tools available for tracking physical activity. Future studies might explore the use of other available tools like Jawbone and Withings which may offer slightly different features, or improved accuracy. And finally, while the Fitbit played an integral part of our intervention, we recommend that such an instrument (or a similar one) be used primarily as a health promotion tool until such time commercial accelerometers are validated for use as a measure of not only step activity, but also activity intensity, activity classification (e.g., is the classification “very active” truly equivalent to vigorous activity?), sedentary time, and non-wear time.

2. While our intervention was guided by key theoretical determinants, the outcomes from mediation, moderation and correlation analyses did not reveal any significant outcomes. However, we did observe a positive relationship between autonomy and tailoring, as well as controlled (external) motivation and tailoring. This finding might be important in developing online physical activity programs, but future studies with larger sample sizes are needed to determine if the observed relationship is in fact significant, and furthermore, if the relationship is clinically meaningful.

Beyond these preliminary findings, research also suggests that future studies explore the use of traditional behavioral theories in interventions using web-based approaches. While the current evidence suggests that there is no significant difference in physical activity outcomes for paper based vs. online delivery of interventions, there is growing debate
about the appropriate use of traditional theories in web-based interventions, and if perhaps new theories are needed. Such theories might explore determinants like development and strength of social networks, self-monitoring, proximal and distal goal-setting, motivation (autonomous vs. external motivators), and message processing (central vs. peripheral), which have all demonstrated promise in the literature.

3. In our intervention, we had a number of participants who were fairly active at baseline despite our screening attempts. As such, we were able to examine how step outcomes differed by group for participants above and below the baseline median steps (data not shown). In these analyses, we observed that tailored participants below the baseline median (~6000 steps) engaged in approximately three times more steps than targeted participants below the baseline median. However, because of small sample sizes in each group, more research is needed to investigate these findings with larger sample sizes, especially because baseline activity has been shown to predict physical activity outcomes. Such a study could further add to the research evidence that online tailored programs are more effective than online targeted programs for promoting physical activity.

4. Our study focused on developing an online tailored intervention to promote physical activity among post-treatment breast cancer survivors. While we were able to demonstrate the need for such an intervention among this growing group of survivors, such a program is certainly not limited to this population. In fact, as the number of colorectal and prostate cancer survivors continues to grow, such a program can be easily adjusted and tested for efficacy among these groups, or even targeted towards prevention
and management of other diseases like diabetes, cardiovascular disease, and obesity. Of course consideration should be given to the types of determinants tailored on as predictors of activity might vary slightly between target populations (e.g., the needs of prostate cancer survivors might differ significantly from the needs of breast cancer survivors).

5. Because our study ultimately tested the added benefit of tailoring over targeting, we have a number of recommendations and insights specifically for this:

   a. *Type of tailoring:*

      In our study, we chose to tailor weekly emails based on objective step activity, type of feedback provided (achieving weekly goals, not achieving weekly goal, no Fitbit wear/no sync), and barriers to exercise. However, the literature supports a number of other physical activity determinants that might have been beneficial to tailor on. These determinants include self-monitoring, autonomy, self-efficacy, problem-solving, etc. (44, 57). Because of the exploratory nature of our intervention, we did not tailor on these determinants. However, future studies might explore the role of such determinants and how to integrate them using web-based delivery.

      There is also mixed evidence in regards to the added benefit of tailoring of physical activity goals versus pre-defined activity goals (120, 122). The mixed evidence is likely due to the heterogeneity in baseline physical activity across study participants. In the referenced studies, it appears that personalized goal-setting may be more beneficial for non-/low-exercisers than those exercisers.
engaging in regular activity. Thus, additional studies among inactive populations are needed to confirm our preliminary findings and hypothesis.

Finally, while there is some suggestive evidence that interventions that tailor on 3-5 determinants are the most successful (44), there is little evidence regarding the most effective number of tailored items needed to promote physical activity. While intuitively it would seem that the more one tailors a program, the more effective it will be, but one still has to take into account the practicality of tailoring on a large number of variables, as well as the added benefit of tailoring on many vs. some variables. Thus, future research might explore these questions as the support for tailoring of web-based interventions continues to grow.

b. Frequency of tailoring:

We chose to tailor feedback and step goals on a weekly basis. While research suggests that tailoring monthly is preferential over tailoring weekly, research also suggests that those starting a new behavior, prefer weekly versus monthly contacts (44). However, this research has not been conducted via web-based approaches, and thus the burden of weekly tailoring and contacts may be greatly reduced. Furthermore, weekly contacts can improve user engagement in web-based studies. Thus, again, future research should investigate how often tailored communications should be made with the participant.

c. Cost of tailoring and need for automation:

Our study followed the guidelines set by Kreuter and colleagues for developing a tailored intervention (7). We developed a large number of tailored messages (grouped by step achievement, step goals, barriers) and integrated these into
weekly emails using Microsoft mail merges. While some software is available to tailor weekly messages (e.g., Michigan Tailoring Software), we had difficulty integrating such messages into our weekly emails without formatting issues. However, as tailoring gains more traction in the commercial world, it is possible that automated programs will be developed and such difficulties will be addressed. Additionally, it is possible that alternative delivery routes might be addressed in future research that does not add burden or cost, especially as support for web-based intervention programs grow.

In summary, this dissertation addressed three gaps in the physical activity literature. First, we demonstrated the validity of a popular commercial accelerometer, the Fitbit Zip, to track daily step activity among healthy adults. We then demonstrated that it is feasible to implement a low-cost, tailored, physical activity program among a national sample of post-treatment breast cancer survivors using only web- and mobile-based technologies. And finally, we demonstrated that weekly tailoring of objective step activity results in greater goal achievement, reduction in self-reported sedentary time, as well as modest changes in step activity among breast cancer survivors.

While the results of this research are encouraging, additional investigation is needed to establish if a tailored, web-based intervention can result in not only significant changes in physical activity, but also clinically-meaningful changes. Furthermore, if such an intervention demonstrates efficacy, additional research will be needed to understand the role of tailoring in maintaining these positive behavioral outcomes, as well as potential theoretical mechanisms via which behavior change takes place.
Lastly, while we demonstrated relative ease in recruiting breast cancer survivors via social media outlets, we had difficulty recruiting minority breast cancer survivors. During our study, we attempted to recruit minority populations via targeted Facebook advertisements, as well as minority breast cancer support groups (e.g., Sisters Network). Facebook advertisements were targeted based on membership to minority breast cancer organizations because targeted advertisements based on race were restricted (although in recent months, advertisers on Facebook can select an option to reach Hispanic Facebook members). Similarly, we contacted local and national breast cancer organizations that had a minority focus or dedicated minority chapter. Ultimately, we were only able to reach a personal contact at the Sisters Network, who helped distribute flyers at a local event for African American breast cancer survivors. The remaining community and national organizations presented more of a challenge for contact. Most organizations and/or support groups required the development of long-lasting professional relationships, requested funding to post any study advertisements, or had organizational policies in place that restricted advertisements of such nature.

Despite these restrictions, there may be more promising avenues to recruit minority breast cancer survivors in future studies. Research studies examining alternative routes to reach minority populations, (not specifically minority breast cancer populations) suggest that the use of a nurse navigator or community representative (e.g., local priest), is a more successful approach to reach such populations (141). This approach helps to develop a relationship between the researcher and the targeted population through building trust and promoting shared-decision making (based on the principles of community-based participatory research (142). Furthermore, such an approach can be adapted for web-based recruitment by developing relationships through online social communities, professional networks, breast cancer organizations, and social media.
support groups. Of course while the use of a nurse navigator or community representative presents a viable solution to reach minority populations, such an approach can also be resource and time intensive, and thus future studies should take this under consideration when developing web-based interventions for minority populations.

As such, future research might explore how best to reach minority populations, determine the best delivery approach (is a self-directed, web-based approach appropriate for reaching minority populations or is a tailored text message better?), identify key determinants for tailoring (what barriers do minority breast cancer survivors face and which of these can be addressed in a web-based study?), and test additional intervention strategies (e.g., the role of community and/or religious/spiritual engagement, the role of social media and networks).
APPENDIX A. Supplemental Tables for AIM 1/ CHAPTER IV

Supplemental Table 4.1: Participant demographics*

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>N=35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age [yrs; mean± SD]</td>
<td>31.8 (9.2)</td>
</tr>
<tr>
<td>Gender:</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>23 (65.7)</td>
</tr>
<tr>
<td>Race</td>
<td></td>
</tr>
<tr>
<td>Non-Hispanic White</td>
<td>26 (74.3)</td>
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<tr>
<td>African American</td>
<td>3 (8.6)</td>
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<tr>
<td>Asian</td>
<td>6 (17.1)</td>
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<tr>
<td>Marital Status</td>
<td></td>
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<tr>
<td>Married or Living with a Partner</td>
<td>15 (42.9)</td>
</tr>
<tr>
<td>Divorced</td>
<td>1 (2.9)</td>
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<tr>
<td>Never Been Married</td>
<td>19 (54.3)</td>
</tr>
<tr>
<td>Education Level</td>
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<tr>
<td>Some College</td>
<td>1 (2.9)</td>
</tr>
<tr>
<td>College Graduate</td>
<td>11 (31.4)</td>
</tr>
<tr>
<td>Post Graduate/ Professional</td>
<td>23 (65.7)</td>
</tr>
<tr>
<td>Occupation</td>
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</tr>
<tr>
<td>Employed</td>
<td>15 (42.9)</td>
</tr>
<tr>
<td>Retired</td>
<td>1 (2.86)</td>
</tr>
<tr>
<td>Student</td>
<td>19 (54.3)</td>
</tr>
<tr>
<td>Annual Income≥ $50,000 **</td>
<td>15 (46.9)</td>
</tr>
<tr>
<td>Body Mass Index [kg/m²; mean± SD]</td>
<td>24.5(5.5)</td>
</tr>
<tr>
<td>General Health</td>
<td></td>
</tr>
<tr>
<td>Excellent</td>
<td>10 (28.6)</td>
</tr>
<tr>
<td>Very Good</td>
<td>14 (40)</td>
</tr>
<tr>
<td>Good</td>
<td>10 (28.6)</td>
</tr>
<tr>
<td>Fair</td>
<td>1 (2.9)</td>
</tr>
</tbody>
</table>

*Characteristics reported as n (%) unless otherwise stated.
**n=32
Supplemental Table 4.2: Referenced Activity Cut Points

<table>
<thead>
<tr>
<th></th>
<th>Sedentary (CPM)</th>
<th>Light (CPM)</th>
<th>Moderate (CPM)</th>
<th>Vigorous (CPM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freedson, 1998</td>
<td>&lt;100</td>
<td>Light: 100</td>
<td>1952</td>
<td>5725</td>
</tr>
<tr>
<td>Freedson, 2011 (80)</td>
<td>n/a</td>
<td>0</td>
<td>2691</td>
<td>6167</td>
</tr>
<tr>
<td>Matthew</td>
<td>&lt;100</td>
<td>100</td>
<td>760</td>
<td>5725</td>
</tr>
<tr>
<td>NHANES (77)</td>
<td>&lt;100</td>
<td>100</td>
<td>2020</td>
<td>5999</td>
</tr>
</tbody>
</table>
APPENDIX B. Example of Step by Step Recruitment Materials

Screenshot of study webpage and Facebook webpage:
Are you a breast cancer survivor? Are you looking to get more exercise? If so, you may be eligible for Step by Step, a 12-week online research study. Check out more information here and to see if you qualify: http://www.stepbystepstudy.org/

via Step by Step Research Study
I qualified and I just took the first survey. I'm in. Who will be joining me?

Step by Step: A walking program for breast cancer survivors
www.stepbystepstudy.org
Welcome to the Step by Step research study! Congratulations, you've taken the first step to improve your health! As a breast cancer survivor, you know the value and importance of keeping your mind...

Like · September 9 at 3:32pm · 🎉
5 people like this.

Awesomesauce! Let us know how it goes!
September 9 at 3:39pm · Like · 1

I will get my FitBit soon and I think I'll get my FitBit soon and I think I will be sharing my progress so I stay on track!!!! (Maybe, I'll share.. or maybe, I'll just let the researchers see!!)
September 9 at 3:46pm · Like

No, share, we can become fitbit friends 😊 LOL!
September 9 at 3:52pm · Like · 1

I didn't qualify... 😞
September 9 at 4:23pm · Like

(on a separate note.... did you see Milwaukee Dome will be lighted in METAvivor colors for the entire weekend of October 13th??????!!! That's damn exciting!!)
September 9 at 4:26pm · Like · 1

I did see that! It is very exciting!!!
September 9 at 4:48pm · Like
APPENDIX C. Organizations asked to share recruitment materials

Academy of Nutrition and Dietetics—Oncology group
Army of Women/ Dr. Susan Love (Denied request)
Black women’s Support Network/Alumni (Cornell)
BreastCancerTrials.org
ClinicalTrials.gov
Cornucopia Cancer Center
Facebook (breast cancer support groups, private announcements, etc.)
Komen (local chapter contact): Denied
LiveStrong Foundation
Living Beyond Breast Cancer (Web and Facebook Page)

The Step by Step Study
The Step by Step research study is recruiting women affected by breast cancer for a free, 12-week walking program facilitated online.

Read more

National Cancer Institute
North Carolina Public Health Association
Pink Broomstick
Pink Warrior Sisters
Pretty in Pink Foundation
Sister's Network (local chapter, flyers)
Twitter

@StepbyStepStudy I’m IN and I’m the first twitter follower, too! Breast cancer & exercise study. Time to get moving! #bcs

03:29 PM - 09 Sep 13

UNC NC Tracs
UNC Student and Employee Listserv
NOW on Doctor Radio's Oncology show, we're talking with one of the researchers behind the Step By Step study, which is recruiting women with breast cancer. Call 877-698-3627 with your question, or visit their website! [http://www.stepbystepstudy.org/index.html](http://www.stepbystepstudy.org/index.html)

**Step by Step: A walking program for breast cancer survivors**

www.stepbystepstudy.org

A walking program for breast cancer survivors
### APPENDIX D. *Step by Step* Weekly Lesson Topics

<table>
<thead>
<tr>
<th>Week</th>
<th>Lesson Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1</td>
<td>Welcome, Introduction to steps and tracking, Suggested exercise plan and step goal</td>
</tr>
<tr>
<td>Week 2</td>
<td>Benefits of exercise, Barriers (tailored/targeted), Problem-solving barriers (tailored/targeted), Step feedback (tailored only), Step goal (tailored/targeted)</td>
</tr>
<tr>
<td>Week 3</td>
<td>Staying Motivated (tailored/targeted), Setting SMART goals (tailored/targeted), Step feedback (tailored only), Step goal (tailored/targeted)</td>
</tr>
<tr>
<td>Week 4</td>
<td>Social Support (tailored/targeted), Step feedback (tailored only), Step goal (tailored/targeted)</td>
</tr>
<tr>
<td>Week 5</td>
<td>Enjoying Activity (tailored/targeted), Step feedback (tailored only), Step goal (tailored/targeted)</td>
</tr>
<tr>
<td>Week 6</td>
<td>Myths and Facts about Exercise/BC survivorship (tailored/targeted), Step feedback (tailored only), Step goal (tailored/targeted)</td>
</tr>
<tr>
<td>Week 7</td>
<td>Fueling for Exercise (Nutrition) (tailored/targeted), Step feedback (tailored only), Step goal (tailored/targeted)</td>
</tr>
<tr>
<td>Week 8</td>
<td>Sitting (tailored/targeted), Step feedback (tailored only), Step goal (tailored/targeted)</td>
</tr>
<tr>
<td>Week 9</td>
<td>Stretching (tailored/targeted), Summary report (tailored only), Step feedback (tailored only), Step goal (tailored/targeted)</td>
</tr>
<tr>
<td>Week 10</td>
<td>Resistance training, Step feedback (tailored only), Step goal (tailored/targeted), Suggested routine (tailored/targeted)</td>
</tr>
<tr>
<td>Week 11</td>
<td>Putting it All Together (tailored/targeted), Step feedback (tailored only), Step goal (tailored/targeted)</td>
</tr>
<tr>
<td>Week 12</td>
<td>Step feedback (tailored only), Step goal (tailored/targeted)</td>
</tr>
</tbody>
</table>
### APPENDIX E. *Step by Step* Sample Barrier Messages

<table>
<thead>
<tr>
<th>Barrier</th>
<th>Message</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Weather</strong></td>
<td>On days that it’s just too hot, cold, or rainy, having a backup exercise plan can help you reach your weekly step goals. For example, you may get in some quick steps by walking on a treadmill, taking the stairs at work, taking a dance class, walking around the mall, or even your local grocery store!</td>
</tr>
<tr>
<td><strong>Time</strong></td>
<td>The top reason busy women state for not getting in enough exercise is lack of time. And who can blame you? Jobs, family, and friends can all take up time in your busy schedule. But it’s important to schedule time for your needs, too. Can you identify 30 minutes in your day (even in blocks of just 10 minutes) where you could do some exercise? Putting exercise in your schedule makes it a priority. You could also try adding in activity to your regular routine—taking the stairs, parking further away from your destination, taking the dog for regular walks, or even trying family walks after a meal.</td>
</tr>
<tr>
<td><strong>Tired/ Lack of motivation</strong></td>
<td>Getting motivated to exercise can be difficult when you're feeling tired... and when you don't have a motivation plan. If you know you're too tired to exercise in the evening, you might plan to boost your day with activity in the morning and at lunch time. Or, if you know you're too tired to exercise in the morning, try a &quot;lunch and evening&quot; walking schedule. You might also try laying out your workout clothes the night before, or scheduling a walking meeting with a colleague or friend. Remember, planning for exercise can give you the boost of motivation when you need it most!</td>
</tr>
<tr>
<td><strong>Joint Pain</strong></td>
<td>We understand that getting motivated to exercise can be difficult when you’re experiencing joint and/or body pain. If you find that your pain disrupts your routine, your best weapon for staying on track with your activity is <em>planning for such days</em>. For example, on days that you feel well, aim to reach your exercise goals. But on days that you experience pain or discomfort, go gentle on your body. Remember, you know your body best—challenge it when you feel good, and rest it when you don’t.</td>
</tr>
<tr>
<td><strong>Cost</strong></td>
<td>Not everyone can afford a gym membership to the swanky new club in town. But the truth is that you don’t need to shell out of a lot of cash so you can exercise. You might want to check out if your community already has a walking program in your area—and if not, you may consider starting one. Other inexpensive ways to get in exercise can be by using what’s already available to you. Walking or jogging along sidewalks, or doing strength building exercises using items lying around the house. Check out this list for more ideas! List: <a href="http://www.mayoclinic.com/health/fitness/HQ00694_D">Link</a></td>
</tr>
</tbody>
</table>
APPENDIX F. Example of Step by Step Weekly Emails

Example of a Tailored Email:

Dear ________

Congratulations, you are now in the final two weeks of the Step by Step research study. In this email, you will find information on how to put together all that you have learned so far in the program. You will also find your weekly feedback on your step progress.

_______’S TOOL BOX: PUTTING IT ALL TOGETHER

During the 12-week study, you’ve gained a lot of new skills to not only motivate you, but also to help you develop a weekly exercise routine. As you move forward through the remainder of the study, use these skills to enhance your experience and get the most out of the Step by Step program:

- **Set SMART Goals**—defining your exercise routine by creating goals that are specific, measurable, and practical.
- **Face your Barriers**—acknowledging your challenges and identifying practical solutions for them.
- **Find your Motivation**—learning to enjoy exercise by engaging in activities you like.
- **Engage your Social Network**—scheduling exercise company (a friend, family member or even a coworker) to help you feel supported.

_______’S TOOL BOX: PUTTING IT ALL TOGETHER

- **Empower Yourself**—having the power to choose when, where, and with whom you want to exercise.
- **Sit Less and Move More**—don’t be a drag, get up and move every few hours!
- **Make Every Step Count**—quite literally, every step you take is a step towards your goal. Don’t hesitate to push yourself to take an extra 30 steps, run on the spot, or go a little crazy with a dance party in front of the mirror. Small steps make a large difference.

**WEEKLY STEP FEEDBACK FOR ________:**

We just took a look at your steps, and all we can say is WOW! This week, you took an average of 10,445 daily steps. Excellent work on meeting your step goal in the second to last week of the Step by Step program!

As an active and empowered breast cancer survivor, you can help reach your exercise goals. Small weekly changes and sustainable goals are important, but knowing that you have a choice in how you reach those goals, is your key to success.

Looking at your progress report below, it looks like you really pushed yourself last Sunday, Tuesday, Wednesday, and Friday. What can you do this week to achieve a similar success?

This week, your suggested step goal is 10,945 daily steps. If you want more of a challenge, try aiming for 11,395 steps 2-3 times this week. To help you reach your goal, we suggest pacing at least two or three of the Step by Step tasks you’ve learned so far. Remember, the national recommendation is 10,000 steps a day—what can you do to reach your goal this week?

When you’re ready, click [here](#) to log in and set your weekly goal!
Example of a Targeted Email:

Dear Beryl,

You have now reached the final two weeks of the Step by Step research study. In this email, you will find information on how to put together all that you have learned so far in the program. You will also find your weekly feedback on your step progress.

**BERYL’S TOOL BOX: PUTTING IT ALL TOGETHER**

During the 12-week study, you’ve gained a lot of new skills to not only motivate you, but also to help you develop a weekly exercise routine. As you move forward through the remainder of the study, use these skills to enhance your experience and get the most out of the Step by Step program.

- **Set S.M.A.R.T Goals**—defining your exercise routine by creating goals that are specific, measurable, and practical.
- **Face your Barriers**—acknowledging your challenges and identifying practical solutions for them.
- **Find your Motivation**—learning to enjoy exercise by engaging in activities you like.
- **Engage your Social Network**—scheduling exercise company (a friend, family member or even coworker) to help you feel supported.

- **Sit Less, and Move More**—don’t be a drag, get up and move every few hours!
- **Make Every Step Count**—quite literally, every step you take is a step towards your goal. Don’t hesitate to push yourself to take an extra 50 steps, run on the spot, or go a little crazy with a dance party in front of the mirror. Small steps make a large difference.

**WEEKLY STEPS FOR BERYL:**

We just took a look at your step progression, and it looks like you took an average of 9913 steps this week. How did you do compared to the recommended step goal?

Based on the national recommended step progression towards 10,000 daily steps, we suggest this week’s step goal be at least 9000 steps.

When you’re ready, click [here](#) to log-in and set your weekly goal.
APPENDIX G. Step by Step Baseline Questionnaire

DEMOGRAPHICS:

Before we begin, please tell us a little about yourself. Click the Next button to begin.

How did you hear about this study? Check all that apply:

- Website
- Facebook
- Email
- Listserv
- Flyer
- Announcement
- Friend or family member
- Other: ____________________

What is your age?

- Give range: <45-65

Are You Hispanic or Latino?

- Yes (1)
- No (2)
- Don't Know (3)

Select which of the following race(s) best describes you?

- White/Caucasian (1)
- Black or African American (2)
- Asian (3)
- American Indian or Alaska Native (4)
- Native Hawaiian or Pacific Islander (5)
- Other (6) ____________________
- Don't Know (7)

Thinking about members of your family living in your household, what is your combined annual income, meaning the total pretax income from all sources earned in the past year?

- $0 to $9,999 (1)
- $10,000 to $14,999 (2)
- $15,000 to $19,999 (3)
- $20,000 to $34,999 (4)
- $35,000 to $49,999 (5)
- $50,000 to $74,999 (6)
- $75,000 to $99,999 (7)
- $100,000 to $199,999 (8)
- $200,000 or more (9)
- Don't Know (10)

**What is your current occupational status?**

- Employed (1)
- Retired (2)
- Homemaker (3)
- Student (4)
- Unemployed (5)
- Don't Know (6)

**What is the highest level of schooling you have completed?**

- Less than High School (1)
- High School Graduate (2)
- Vocational/ Trade School Graduate (3)
- Some College (4)
- College Graduate (5)
- Postgraduate/ Professional (6)
- Don't Know (7)

**What is your marital status?**

- Married (1)
- Divorced (2)
- Widowed (3)
- Separated (4)
- Never been Married (5)
- Living with a Partner (6)
- Don't Know (7)

**Have you smoked at least 100 cigarettes in your entire life?  Note: 5 packs= 100 cigarettes**

- Yes (1)
- No (2)
- Don't Know (3)

**Do you now smoke cigarettes every day, some days, or not at all?**

- Every day (1)
- Some days (2)
- Not at all (3)
In general, would you say your health is:

- Excellent (1)
- Very Good (2)
- Good (3)
- Fair (4)
- Poor (5)

CANCER HISTORY

At what age were you diagnosed with breast cancer?

______________

What type of treatment did you receive for your breast cancer? Please check all that apply:

- Surgery
- Chemotherapy
- Radiation
- None
- Don’t know
- Other: _________

Are you currently taking an Aromatase Inhibitor? Aromatase Inhibitors are a type of drug prescribed to some breast cancer survivors following primary treatment.

Examples of this type of drug may include: Arimidex®, Aromasin®, Femara®.

- Yes
- No

Godin Leisure Time Exercise Questionnaire

1. Considering a 7-day period (a week) how many times on the average do you do the following kinds of exercise for more than 15 minutes during your free time? (write on each line the appropriate number).)

a) STRENUOUS EXERCISE (HEART BEATS RAPIDLY)
(e.g., running, jogging, hockey, football, soccer, squash, basketball, cross country skiing, judo, roller skating, vigorous swimming, vigorous long distance bicycling)

1) Times per week:

□ Don’t know/Not sure

2) _____ minutes per day

b) MODERATE EXERCISE (NOT EXHAUSTING)

(e.g., fast walking, baseball, tennis, easy bicycling, volleyball, badminton, easy swimming, alpine skiing, popular and folk dancing)

1) Times per week:

□ Don’t know/Not sure

2) How much time did you usually spend doing **moderate exercise** on one of those days?

_____ minutes per day

□ Don’t know/Not sure

c) MILD EXERCISE (MINIMAL EFFORT)

(e.g., yoga, archery, fishing from river bank, bowling, horseshoes, golf, snow-mobiling, easy walking)

1) Times per week:

□ Don’t know/Not sure

2) How much time did you usually spend doing **strenuous exercise** on one of those days?

_____ minutes per day

□ Don’t know/Not sure

2. During a typical 7-Day period (a week), in your leisure time, how often do you engage in any regular activity long enough to work up a sweat (heart beats rapidly)?

a. **OFTEN**
b. Sometimes

c. Never/Rarely

FRUITS AND VEGETABLES (2-item): HINTS

About how many cups of fruit (including 100% pure fruit juice) do you eat or drink each day? 1 cup of fruit could be: 1 small apple 1 large banana 1 large orange 8 large strawberries 1 medium pear 2 large plums 32 seedless grapes 1 cup (8 oz.) fruit juice ½ cup dried fruit 1 inch thick wedge of watermelon

☐ None (1)
☐ 1/2 cup or less (2)
☐ 1/2 cup to 1 cup (3)
☐ 1 to 2 cups (4)
☐ 2 to 3 cups (5)
☐ 3 to 4 cups (6)
☐ 4 or more cups (7)

About how many cups of vegetables (including 100% pure vegetable juice) do you eat or drink each day? 1 cup of vegetables could be: 3 broccoli spears 1 cup cooked leafy greens 2 cups lettuce or raw greens 12 baby carrots 1 medium potato 1 large sweet potato 1 large ear of corn 1 large raw tomato 2 large celery sticks 1 cup of cooked beans

☐ None (1)
☐ 1/2 cup or less (2)
☐ 1/2 cup to 1 cup (3)
☐ 1 to 2 cups (4)
☐ 2 to 3 cups (5)
☐ 3 to 4 cups (6)
☐ 4 or more cups (7)

Sedentary Behavior:

1. The last question is about the time you spent sitting on weekdays while at work, at home, while doing course work and during leisure time. This includes time spent sitting at a desk, visiting friends, reading traveling on a bus or sitting or lying down to watch television.

During the last 7 days, how much time in total did you usually spend sitting on a week day?

_____ hours ______ minutes

2. Over the past 7 days, on average how many hours per day did {you/SP} sit and watch TV or videos? Would you say . . .
You do not watch TV or videos
DON'T KNOW

**Barrier self-efficacy**

*How confident are you that you can exercise:*

1. **When I lack discipline to exercise**

<table>
<thead>
<tr>
<th>Not at all confident</th>
<th>Slightly confident</th>
<th>Moderately confident</th>
<th>Very confident</th>
<th>Extremely confident</th>
<th>Not applicable</th>
</tr>
</thead>
</table>

2. **When I feel joint or body pain**

<table>
<thead>
<tr>
<th>Not at all confident</th>
<th>Slightly confident</th>
<th>Moderately confident</th>
<th>Very confident</th>
<th>Extremely confident</th>
<th>Not applicable</th>
</tr>
</thead>
</table>

3. **When exercise is not a priority**

<table>
<thead>
<tr>
<th>Not at all confident</th>
<th>Slightly confident</th>
<th>Moderately confident</th>
<th>Very confident</th>
<th>Extremely confident</th>
<th>Not applicable</th>
</tr>
</thead>
</table>

4. **When the weather is bad**

<table>
<thead>
<tr>
<th>Not at all confident</th>
<th>Slightly confident</th>
<th>Moderately confident</th>
<th>Very confident</th>
<th>Extremely confident</th>
<th>Not applicable</th>
</tr>
</thead>
</table>

5. **When I am tired**

<table>
<thead>
<tr>
<th>Not at all confident</th>
<th>Slightly confident</th>
<th>Moderately confident</th>
<th>Very confident</th>
<th>Extremely confident</th>
<th>Not applicable</th>
</tr>
</thead>
</table>

6. **When I am not interested in exercising**

<table>
<thead>
<tr>
<th>Not at all confident</th>
<th>Slightly confident</th>
<th>Moderately confident</th>
<th>Very confident</th>
<th>Extremely confident</th>
<th>Not applicable</th>
</tr>
</thead>
</table>

7. **When I lack time**

<table>
<thead>
<tr>
<th>Not at all confident</th>
<th>Slightly confident</th>
<th>Moderately confident</th>
<th>Very confident</th>
<th>Extremely confident</th>
<th>Not applicable</th>
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</table>

8. **When I do not enjoy exercising**

<table>
<thead>
<tr>
<th>Not at all confident</th>
<th>Slightly confident</th>
<th>Moderately confident</th>
<th>Very confident</th>
<th>Extremely confident</th>
<th>Not applicable</th>
</tr>
</thead>
</table>
9. When I do not have someone to encourage me to exercise

<table>
<thead>
<tr>
<th>Not at all confident</th>
<th>Slightly confident</th>
<th>Moderately confident</th>
<th>Very confident</th>
<th>Extremely confident</th>
<th>Not applicable</th>
</tr>
</thead>
</table>

**Task self-efficacy**

1. *I can walk briskly for 20 min without stopping*

<table>
<thead>
<tr>
<th>Not at all confident</th>
<th>Slightly confident</th>
<th>Moderately confident</th>
<th>Very confident</th>
<th>Extremely confident</th>
<th>Not applicable</th>
</tr>
</thead>
</table>

2. *I can run or jog for 10 min without stopping*

<table>
<thead>
<tr>
<th>Not at all confident</th>
<th>Slightly confident</th>
<th>Moderately confident</th>
<th>Very confident</th>
<th>Extremely confident</th>
<th>Not applicable</th>
</tr>
</thead>
</table>

3. *I can climb three flights of stairs without stopping*

<table>
<thead>
<tr>
<th>Not at all confident</th>
<th>Slightly confident</th>
<th>Moderately confident</th>
<th>Very confident</th>
<th>Extremely confident</th>
<th>Not applicable</th>
</tr>
</thead>
</table>

4. *I can exercise for 20 min at a level hard enough to cause a large increase in heart rate and breathing*

<table>
<thead>
<tr>
<th>Not at all confident</th>
<th>Slightly confident</th>
<th>Moderately confident</th>
<th>Very confident</th>
<th>Extremely confident</th>
<th>Not applicable</th>
</tr>
</thead>
</table>

**Exercise goal-setting scale (EGS)**

The following questions refer to how you set exercise goals and plan exercise activities. Please indicate the extent to which each of the statements below describes you:

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does Not Describe</td>
<td>Describes Moderately</td>
<td>Describes Completely</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. I often set exercise goals
2. I usually have more than one major exercise goal
3. I usually set dates for achieving my exercise goals
4. My exercise goals help to increase my motivation for doing exercise
5. I tend to break more difficult exercise goals down into a series of smaller goals
6. I usually keep track of my progress in meeting my goals
7. I have developed a series of steps for reaching my exercise goals
8. I usually achieve the exercise goals I set for myself
9. If I do not reach an exercise goal, I analyze what went wrong
10. I make my exercise goals public by telling other people about them

Treatment self-regulation Questionnaire (TSRQ for exercise)

The following question relates to the reasons why you would either start to exercise regularly or continue to do so. Different people have different reasons for doing that, and we want to know how true each of the following reasons is for you.

All 15 responses are to the one question.

Please indicate the extent to which each reason is true for you, using the following 7-point scale:

<table>
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<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not at all true</td>
<td></td>
<td></td>
<td>Somewhat true</td>
<td></td>
<td></td>
<td>Very true</td>
</tr>
</tbody>
</table>

The reason I would exercise regularly is:

1. Because I feel that I want to take responsibility for my own health.
2. Because I would feel guilty or ashamed of myself if I did not exercise regularly.
3. Because I personally believe it is the best thing for my health.
4. Because others would be upset with me if I did not.
5. I really don't think about it.
6. Because I have carefully thought about it and believe it is very important for many aspects of my life.
7. Because I would feel bad about myself if I did not exercise regularly.
8. Because it is an important choice I really want to make.
9. Because I feel pressure from others to do so.
10. Because it is easier to do what I am told than think about it.
11. Because it is consistent with my life goals.
12. Because I want others to approve of me.
13. Because it is very important for being as healthy as possible.
14. Because I want others to see I can do it.
Health Care Climate Questionnaire for Exercising Regularly

This questionnaire contains items that are related to your visits with your health-care practitioners in which exercise was discussed in any way. Health-care practitioners (doctors, nurses, counselors, etc.) have different styles in dealing with patients, and we would like to know very specifically about how you felt about your encounters with the individuals who you have met with and discussed your activity. Your responses will be kept confidential, so none of your practitioners will know about your responses. Please be honest and candid. Please circle the responses that best represent your feelings. In some cases, you may have met with only your physician; in other cases you may have discussed your exercising regimen with several people. Please answer in terms of the sense you have about all these practitioners together.

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<th>1</th>
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<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I feel that my health-care providers have provided me with choices and options about exercising regularly (including not exercising regularly).</td>
<td>Not at all true</td>
<td></td>
<td></td>
<td>Somewhat true</td>
<td></td>
<td></td>
<td>Very true</td>
</tr>
<tr>
<td>2. I feel my health-care practitioners understand how I see things with respect to my exercising regularly.</td>
<td></td>
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<td></td>
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<tr>
<td>3. My health-care providers convey confidence in my ability to make changes regarding my exercising regularly.</td>
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</tr>
<tr>
<td>4. My health care practitioner(s) listen(s) to how I would like to do things regarding my exercise.</td>
<td></td>
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<tr>
<td>5. My health-care practitioners encourage me to ask questions regarding my exercise.</td>
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<tr>
<td>6. My health-care practitioners try to understand how I see my exercising before suggesting any changes.</td>
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Perceived Competence Scale (PCS) for Exercising Regularly:

Please read each item and circle the number that indicates your level of agreement with that statement, assuming that you were intending to permanently change your exercise regimen now.

<table>
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<th>1</th>
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<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I feel confident in my exercising regularly.</td>
<td>Not at all true</td>
<td></td>
<td></td>
<td>Somewhat true</td>
<td></td>
<td></td>
<td>Very true</td>
</tr>
</tbody>
</table>
2. I feel capable of exercising regularly now.
3. I am able to exercise regularly now.
4. I am able to meet the challenge exercising regularly.

Follow up:
Thank you for completing this questionnaire.

In order for us to mail you the Welcome Package with your FitBit, please provide your mailing address below:

First Name: ______________
Last Name: ______________
Preferred Name: ______________
Email Address: ______________
Address: ______________
__________________________
Telephone Number: ______________

Thank you, your Welcome Package will be on its way to you shortly.

Help us get out the word:

If you know of other women, or even a group of women, who may benefit from this research study, please pass along our study information to help get out the word!

Website: http://stepbystepstudy.org
Email: stepbystep@unc.edu
APPENDIX H. *Step by Step* Midpoint Questionnaire

The following survey will help us to learn more about you, and continue to create an exercise plan that works for you. It may take up to 10 minutes to complete the survey.

As a reminder, all information collected will be kept confidential. At any time you may choose to skip a question if you prefer not to answer it.

If you have any questions, please contact us at stepbystep@unc.edu

Once you’re ready, click Next to continue.

**Barrier self-efficacy**

*How confident are you that you can exercise:*

<table>
<thead>
<tr>
<th>10. When I lack discipline to exercise</th>
<th>Not at all confident</th>
<th>Slightly confident</th>
<th>Moderately confident</th>
<th>Very confident</th>
<th>Extremely confident</th>
<th>Not applicable</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>11. When I feel joint or body pain</th>
<th>Not at all confident</th>
<th>Slightly confident</th>
<th>Moderately confident</th>
<th>Very confident</th>
<th>Extremely confident</th>
<th>Not applicable</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>12. When exercise is not a priority</th>
<th>Not at all confident</th>
<th>Slightly confident</th>
<th>Moderately confident</th>
<th>Very confident</th>
<th>Extremely confident</th>
<th>Not applicable</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>13. When the weather is bad</th>
<th>Not at all confident</th>
<th>Slightly confident</th>
<th>Moderately confident</th>
<th>Very confident</th>
<th>Extremely confident</th>
<th>Not applicable</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>14. When I am tired</th>
<th>Not at all confident</th>
<th>Slightly confident</th>
<th>Moderately confident</th>
<th>Very confident</th>
<th>Extremely confident</th>
<th>Not applicable</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>15. When I am not interested in exercising</th>
<th>Not at all confident</th>
<th>Slightly confident</th>
<th>Moderately confident</th>
<th>Very confident</th>
<th>Extremely confident</th>
<th>Not applicable</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>16. When I lack time</th>
<th>Not at all confident</th>
<th>Slightly confident</th>
<th>Moderately confident</th>
<th>Very confident</th>
<th>Extremely confident</th>
<th>Not applicable</th>
</tr>
</thead>
</table>
17. When I do not enjoy exercising

<table>
<thead>
<tr>
<th>Not at all confident</th>
<th>Slightly confident</th>
<th>Moderately confident</th>
<th>Very confident</th>
<th>Extremely confident</th>
<th>Not applicable</th>
</tr>
</thead>
</table>

18. When I do not have someone to encourage me to exercise

<table>
<thead>
<tr>
<th>Not at all confident</th>
<th>Slightly confident</th>
<th>Moderately confident</th>
<th>Very confident</th>
<th>Extremely confident</th>
<th>Not applicable</th>
</tr>
</thead>
</table>

**Task self-efficacy**

5. I can walk briskly for 20 min without stopping

<table>
<thead>
<tr>
<th>Not at all confident</th>
<th>Slightly confident</th>
<th>Moderately confident</th>
<th>Very confident</th>
<th>Extremely confident</th>
<th>Not applicable</th>
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6. I can run or jog for 10 min without stopping

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<th>Not at all confident</th>
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<th>Moderately confident</th>
<th>Very confident</th>
<th>Extremely confident</th>
<th>Not applicable</th>
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7. I can climb three flights of stairs without stopping

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<th>Extremely confident</th>
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8. I can exercise for 20 min at a level hard enough to cause a large increase in heart rate and breathing

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<th>Moderately confident</th>
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**Exercise goal-setting scale (EGS)**

The following questions refer to how you set exercise goals and plan exercise activities. Please indicate the extent to which each of the statements below describes you:

1. | 2 | 3 | 4 | 5 |
---|---|---|---|---|
Does Not Describe: | Describes | Moderately | | Describes Completely |

1. I often set exercise goals
2. I usually have more than one major exercise goal
3. I usually set dates for achieving my exercise goals
4. My exercise goals help to increase my motivation for doing exercise
5. I tend to break more difficult exercise goals down into a series of smaller goals
6. I usually keep track of my progress in meeting my goals
7. I have developed a series of steps for reaching my exercise goals
8. I usually achieve the exercise goals I set for myself
9. If I do not reach an exercise goal, I analyze what went wrong
10. I make my exercise goals public by telling other people about them

**Treatment self-regulation Questionnaire (TSRQ for exercise)**

The following question relates to the reasons why you would either start to exercise regularly or continue to do so. Different people have different reasons for doing that, and we want to know how true each of the following reasons is for you.

**All 15 responses are to the one question.**

Please indicate the extent to which each reason is true for you, using the following 7-point scale:

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The reason I would exercise regularly is:

1. Because I feel that I want to take responsibility for my own health.
2. Because I would feel guilty or ashamed of myself if I did not exercise regularly.
3. Because I personally believe it is the best thing for my health.
4. Because others would be upset with me if I did not.
5. I really don't think about it.
6. Because I have carefully thought about it and believe it is very important for many aspects of my life.
7. Because I would feel bad about myself if I did not exercise regularly.
8. Because it is an important choice I really want to make.
9. Because I feel pressure from others to do so.
10. Because it is easier to do what I am told than think about it.
11. Because it is consistent with my life goals.
12. Because I want others to approve of me.
13. Because it is very important for being as healthy as possible.
14. Because I want others to see I can do it.
15. I don't really know why.

**Health Care Climate Questionnaire for Exercising Regularly**

This questionnaire contains items that are related to your visits with your health-care practitioners in which exercise was discussed in any way. Health-care practitioners (doctors, nurses, counselors, etc.) have different styles in dealing with patients, and we would like to know very specifically about how you felt about your encounters with the individuals who you have met with and discussed exercise. Your responses will be kept confidential, so none of your practitioners will know about your responses. Please be honest and candid. Please circle the responses that best represent your feelings. In some cases, you may have met with only your physician; in other cases you may have discussed your exercising regimen with several people. Please answer in terms of the sense you have about all these practitioners together.

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<td>Somewhat true</td>
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<td>Very true</td>
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1. I feel that my health-care providers have provided me with choices and options about exercising regularly (including not exercising regularly).
2. I feel my health-care practitioners understand how I see things with respect to my exercising regularly.
3. My health-care providers convey confidence in my ability to make changes regarding my exercising regularly.
4. My health care practitioner(s) listen(s) to how I would like to do things regarding my exercise.
5. My health-care practitioners encourage me to ask questions regarding my exercise.
6. My health-care practitioners try to understand how I see my exercising before suggesting any changes.

**Perceived Competence Scale (PCS) for Exercising Regularly:**

Please read each item and circle the number that indicates your level of agreement with that statement, assuming that you were intending to permanently change your exercise regimen now.
| Not at all true | | Somewhat true | | Very true |

1. I feel confident in my exercise regularly.
2. I feel capable of exercising regularly now.
3. I am able to exercise regularly now.
4. I am able to meet the challenge exercising regularly.

Thank you, your midpoint survey has now been completed.

Help us get out the word:

If you know of other women, or even a group of women, who may benefit from this research study, please pass along our study information to help get out the word!

*Website:* [http://stepbystepstudy.org](http://stepbystepstudy.org)

*Email:* stepbystep@unc.edu
Congratulations! You have now completed the Step by Step research program. We appreciate the time you have taken this far to participate in this important work.

In order for us to evaluate how the Step by Step program worked for you, please complete this final survey. All responses will be kept confidential. You may skip any question you choose not to answer. The survey may take up to 30 minutes to complete.

As a reminder, at the completion of this survey we will send you a $20 gift card to Amazon.com. Only those surveys that are completed will be eligible for this gift card.

If you have any questions or comments, please email us at stepbystep@unc.edu. You may also review the study consent form at: http://stepbystepstudy.org/consent

Again, we thank you for your participation in our research study.

The first set of questions will ask you about your usual activity:

**Godin Leisure Time Exercise Questionnaire**

3. Considering a 7-day period (a week) how many times on the average do you do the following kinds of exercise for more than 15 minutes during your free time? (write on each line the appropriate number.)

a) STRENUOUS EXERCISE (HEART BEATS RAPIDLY)
(e.g., running, jogging, hockey, football, soccer, squash, basketball, cross country skiing, judo, roller skating, vigorous swimming, vigorous long distance bicycling)

   2) Times per week: 

      _____

   How much time did you usually spend doing strenuous exercise on one of those days?

   2) _____ minutes per day

   □ Don’t know/Not sure

b) MODERATE EXERCISE (NOT EXHAUSTING)
(e.g., fast walking, baseball, tennis, easy bicycling, volleyball, badminton, easy swimming, alpine skiing, popular and folk dancing)
3) Times per week: 

_____

4) How much time did you usually spend doing moderate exercise on one of those days?

____ minutes per day

☐ Don’t know/Not sure

c) MILD EXERCISE (MINIMAL EFFORT) 

(e.g., yoga, archery, fishing from river bank, bowling, horseshoes, golf, snow-mobiling, easy walking)

3) Times per week: 

_____

4) How much time did you usually spend doing strenuous exercise on one of those days?

____ minutes per day

☐ Don’t know/Not sure

4. During a typical 7-Day period (a week), in your leisure time, how often do you engage in any regular activity long enough to work up a sweat (heart beats rapidly)?

a. OFTEN
b. SOMETIMES
c. NEVER/RARELY
FRUITS AND VEGETABLES (2-item): HINTS

About how many cups of fruit (including 100% pure fruit juice) do you eat or drink each day? 1 cup of fruit could be: 1 small apple 1 large banana 1 large orange 8 large strawberries 1 medium pear 2 large plums 32 seedless grapes 1 cup (8 oz.) fruit juice ½ cup dried fruit 1 inch thick wedge of watermelon

- None (1)
- 1/2 cup or less (2)
- 1/2 cup to 1 cup (3)
- 1 to 2 cups (4)
- 2 to 3 cups (5)
- 3 to 4 cups (6)
- 4 or more cups (7)

About how many cups of vegetables (including 100% pure vegetable juice) do you eat or drink each day? 1 cup of vegetables could be: 3 broccoli spears 1 cup cooked leafy greens 2 cups lettuce or raw greens 12 baby carrots 1 medium potato 1 large sweet potato 1 large ear of corn 1 large raw tomato 2 large celery sticks 1 cup of cooked beans

- None (1)
- 1/2 cup or less (2)
- 1/2 cup to 1 cup (3)
- 1 to 2 cups (4)
- 2 to 3 cups (5)
- 3 to 4 cups (6)
- 4 or more cups (7)

Sedentary Behavior:

1. The last question is about the time you spent sitting on weekdays while at work, at home, while doing course work and during leisure time. This includes time spent sitting at a desk, visiting friends, reading traveling on a bus or sitting or lying down to watch television.

During the last 7 days, how much time in total did you usually spend sitting on a week day?

____ hours ______ minutes

2. Over the past 30 days, in your leisure time, how many hours per day, on average, did you sit and watch TV or movies, surf the web, or play computer games? Do not include “active gaming” such as Wii.

0 hours
less than 1 hour
1 hour
2 hours
3 hours
4 hours
5 hours or more
You do not watch TV or videos
DON'T KNOW

**Barrier self-efficacy**

*How confident are you that you can exercise:*

<table>
<thead>
<tr>
<th>19. When I lack discipline to exercise</th>
<th>Not at all confident</th>
<th>Slightly confident</th>
<th>Moderately confident</th>
<th>Very confident</th>
<th>Extremely confident</th>
<th>Not applicable</th>
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<th>20. When I feel joint or body pain</th>
<th>Not at all confident</th>
<th>Slightly confident</th>
<th>Moderately confident</th>
<th>Very confident</th>
<th>Extremely confident</th>
<th>Not applicable</th>
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<th>21. When exercise is not a priority</th>
<th>Not at all confident</th>
<th>Slightly confident</th>
<th>Moderately confident</th>
<th>Very confident</th>
<th>Extremely confident</th>
<th>Not applicable</th>
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<th>22. When the weather is bad</th>
<th>Not at all confident</th>
<th>Slightly confident</th>
<th>Moderately confident</th>
<th>Very confident</th>
<th>Extremely confident</th>
<th>Not applicable</th>
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<th>23. When I am tired</th>
<th>Not at all confident</th>
<th>Slightly confident</th>
<th>Moderately confident</th>
<th>Very confident</th>
<th>Extremely confident</th>
<th>Not applicable</th>
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<tr>
<th>24. When I am not interested in exercising</th>
<th>Not at all confident</th>
<th>Slightly confident</th>
<th>Moderately confident</th>
<th>Very confident</th>
<th>Extremely confident</th>
<th>Not applicable</th>
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<th>25. When I lack time</th>
<th>Not at all confident</th>
<th>Slightly confident</th>
<th>Moderately confident</th>
<th>Very confident</th>
<th>Extremely confident</th>
<th>Not applicable</th>
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<tr>
<th>26. When I do not enjoy exercising</th>
<th>Not at all confident</th>
<th>Slightly confident</th>
<th>Moderately confident</th>
<th>Very confident</th>
<th>Extremely confident</th>
<th>Not applicable</th>
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</tbody>
</table>
27. When I do not have someone to encourage me to exercise

| Not at all confident | Slightly confident | Moderately confident | Very confident | Extremely confident | Not applicable |

**Task self-efficacy**

9. I can walk briskly for 20 min without stopping

| Not at all confident | Slightly confident | Moderately confident | Very confident | Extremely confident | Not applicable |

10. I can run or jog for 10 min without stopping

| Not at all confident | Slightly confident | Moderately confident | Very confident | Extremely confident | Not applicable |

11. I can climb three flights of stairs without stopping

| Not at all confident | Slightly confident | Moderately confident | Very confident | Extremely confident | Not applicable |

12. I can exercise for 20 min at a level hard enough to cause a large increase in heart rate and breathing

| Not at all confident | Slightly confident | Moderately confident | Very confident | Extremely confident | Not applicable |

**Exercise goal-setting scale (EGS)**

The following questions refer to how you set exercise goals and plan exercise activities. Please indicate the extent to which each of the statements below describes you:

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<tbody>
<tr>
<td>Does Not Describe</td>
<td>Describes</td>
<td>Moderately</td>
<td>Describes</td>
<td>Completely</td>
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1. I often set exercise goals
2. I usually have more than one major exercise goal
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4. My exercise goals help to increase my motivation for doing exercise
5. I tend to break more difficult exercise goals down into a series of smaller goals
6. I usually keep track of my progress in meeting my goals
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10. I make my exercise goals public by telling other people about them

**Treatment self-regulation Questionnaire (TSRQ for exercise)**

The following question relates to the reasons why you would either start to exercise regularly or continue to do so. Different people have different reasons for doing that, and we want to know how true each of the following reasons is for you.

**All 15 responses are to the one question.**

**Please indicate the extent to which each reason is true for you, using the following 7-point scale:**

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**The reason I would exercise regularly is:**

1. Because I feel that I want to take responsibility for my own health.
2. Because I would feel guilty or ashamed of myself if I did not exercise regularly.
3. Because I personally believe it is the best thing for my health.
4. Because others would be upset with me if I did not.
5. I really don't think about it.
6. Because I have carefully thought about it and believe it is very important for many aspects of my life.
7. Because I would feel bad about myself if I did not exercise regularly.
8. Because it is an important choice I really want to make.
9. Because I feel pressure from others to do so.
10. Because it is easier to do what I am told than think about it.
11. Because it is consistent with my life goals.
12. Because I want others to approve of me.
13. Because it is very important for being as healthy as possible.
14. Because I want others to see I can do it.
15. I don't really know why.

**Health Care Climate Questionnaire for Exercising Regularly**

This questionnaire contains items that are related to your visits with your health-care practitioners in which exercise was discussed in any way. Health-care practitioners (doctors, nurses, counselors, etc.) have different styles in dealing with patients, and we would like to know very specifically about how you felt about your encounters with the individuals who you have met with and discussed exercise. Your responses will be kept confidential, so none of your practitioners will know about your responses. Please be honest and candid. Please circle the responses that best represent your feelings. In some cases, you may have met with only your physician; in other cases you may have discussed your exercising regimen with several people. Please answer in terms of the sense you have about all these practitioners together.

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1. I feel that my health-care providers have provided me with choices and options about exercising regularly (including not exercising regularly).

2. I feel my health-care practitioners understand how I see things with respect to my exercising regularly.

3. My health-care providers convey confidence in my ability to make changes regarding my exercising regularly.

4. My health care practitioner(s) listen(s) to how I would like to do things regarding my exercise.

5. My health-care practitioners encourage me to ask questions regarding my exercise.

6. My health-care practitioners try to understand how I see my exercising before suggesting any changes.

**Perceived Competence Scale (PCS) for Exercising Regularly:**

Please read each item and circle the number that indicates your level of agreement with that statement, assuming that you were intending to permanently change your exercise regimen now.

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<td>Very true</td>
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1. I feel confident in my exercise regularly.
2. I feel capable of exercising regularly now.
3. I am able to exercise regularly now.
4. I am able to meet the challenge exercising regularly.

The following questions refer to how you fit exercise into your lifestyle.

Please indicate the extent to which each of the statements below describes you:

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<td></td>
<td></td>
<td>Somewhat true</td>
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<td>Very true</td>
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</table>

1. I never seem to have enough time to exercise
2. Exercise is generally not a high priority when I plan my schedule
3. Finding time for exercise is difficult for me
4. I schedule all events in my life around my exercise routine
5. I schedule my exercise at specific times each week
6. I plan my weekly exercise schedule
7. When I am very busy, I don’t do much exercise
8. Everything is scheduled around my exercise routine—both classes and work
9. I try to exercise at the same time and same day each week to keep a routine going
10. I write my planned activity sessions in an appointment book or calendar

Elaboration Likelihood Model Questionnaire

Please answer the following questions on a scale of 1 (not at all) to 7 (very much).

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<tr>
<td>Not at all</td>
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<td></td>
<td></td>
<td></td>
<td>Very much</td>
</tr>
</tbody>
</table>
1. How important is the topic of physical activity to you personally?

2. How motivated were you to read the messages in the weekly emails?

3. To what extent did you try hard to think about the information in the weekly emails messages?

4. How much would you say the information in the weekly emails held your attention?

5. How much effort would you say you gave to evaluating the information in the weekly emails?

6. To what extent did you feel you had enough time to think about the information given in the weekly emails?

7. To what extent did you find the information in the weekly emails well organized and easy to follow?

8. In your opinion, how logical and accurate was the information presented in the weekly emails?

9. To what extent would you say the weekly emails made good points about exercising?

**Process Measures:**

1. Over the last twelve weeks do you recall getting any weekly emails from the study?
   - a. Yes
   - b. No

2. How many of the weekly emails do you remember reading?
   - a. 1-3
   - b. 4-6
   - c. 7-9
   - d. 10-12
   - e. None

3. How much of the weekly emails did you usually read?
   - a. None
   - b. A little
   - c. Some
   - d. All/most

4. Did the information shared in the weekly emails change any of your health behaviors?
   - a. Yes
   - b. No
   - c. Don’t know
5. What health changes did you make? Select all that apply.
   - Set daily/ weekly activity goals
   - Planned my daily/ weekly exercise
   - Invited someone to exercise with me
   - Scheduled exercise “dates” with a friend/coworker/ family member
   - Made effort to sit less and move more
   - Problem-solved my barriers to exercise
   - Tried to make activity more enjoyable
   - Added resistance training in my exercise routine
   - Added stretching to my exercise routine
   - Chose healthier food and drink options
   - Other: ___________
   - None of the Above

6. Do you plan to continue with the changes you made?
   a. Yes
   b. No
   c. Don’t know

7. Did you share the information from the emails with any of your friends or family members?
   a. Yes
   b. No
   c. Don’t know

8. Do you feel the number of emails you received was:
   a. Too few
   b. Just right
   c. Too many
   d. Don’t know

9. On average how much time did you spend reading, talking about, or using each email you received?
   a. 1-10 minutes
   b. 11-20 minutes
   c. 21-30 minutes
   d. More than 30 minutes

Thank you. The next few questions will ask you about your use of the Fitbit Website. Click Next to continue when you’re ready.

10. Over the last twelve weeks do you recall any prompts for you to log into the Fitbit website?
    a. Yes
b. No

11. How many times do you remember logging on the Fitbit website?
   a. 1-3
   b. 4-6
   c. 7-9
   d. 10-12
   e. More than 12
   f. None

12. What tools, if any, on the FitBit DASHBOARD do you remember using? Select all that apply:
   a. Step tracker
   b. Exercise Intensity (mild, moderate and very intense)
   c. Distance Tracker
   d. Calorie Tracker
   e. Very Active Minutes Tracker
   f. Top Badges
   g. Connecting with Friends
   h. Other: ___________________
   i. None

13. What tools, if any, on the Fitbit LOG do you remember using? Select all that apply:
   a. Food log
   b. Activities log
   c. Weight log
   d. Journal
   e. Other: ___________________
   f. None

14. Did the information shared in the Fitbit website change any of your health behaviors?
   a. Yes
   b. No
   c. Don’t know

15. What health changes did you make based on the Fitbit website? Select all that apply.
   - Set daily/weekly activity goals
   - Planned my daily/weekly exercise
   - Invited someone to exercise with me
   - Scheduled exercise “dates” with a friend/coworker/family member
   - Made effort to sit less and move more
   - Problem-solved my barriers to exercise
☐ Tried to make activity more enjoyable
☐ Included resistance exercises
☐ Added stretching to my exercise routine
☐ Chose healthier food and drink options
☐ Other: ___________
☐ None of the Above

16. Do you plan to continue with the changes you made?
   a. Yes
   b. No
   c. Don’t know

17. Did you share the information from the Fitbit website with any of your friends or family members?
   a. Yes
   b. No
   c. Don’t know

18. On average how much time did you spend reading, talking about, or using the Fitbit website?
   a. 1-10 minutes
   b. 11-20 minutes
   c. 21-30 minutes
   d. More than 30 minutes

Thank you. The next few questions will ask you about your use of the Fitbit Monitor. Click Next to continue when you’re ready.

19. During the past 12 weeks, how often, on average, did you wear your Fitbit monitor?
   a) Every day
   b) 5-6 times a week
   c) 3-4 times a week
   d) 1-2 times a week
   e) Less than once a week
   f) Other:_________

20. During the past 12 weeks, how often, on average, did you sync your Fitbit monitor?
   g) Every day
   h) Almost every day
   i) 2-3 times a week
   j) Once a week
   k) Less than once a week
   l) Other:_________
21. On average, how often did you check your daily activity by tapping on your Fitbit monitor?
   a. More than twice a day
   b. Twice a day
   c. Once a day
   d. Every 2-3 days
   e. Every 4-5 Days
   f. Once a week
   g. Other: ____________

22. Did the information on the Fitbit monitor change any of your health behaviors?
   a. Yes
   b. No
   c. Don’t know

23. What health changes did you make? Select all that apply.
   - Set daily/ weekly activity goals
   - Planned my daily/ weekly exercise
   - Invited someone to exercise with me
   - Scheduled exercise “dates” with a friend/coworker/ family member
   - Made effort to sit less and move more
   - Problem-solved my barriers to exercise
   - Tried to make activity more enjoyable
   - Included resistance exercises
   - Added stretching to my exercise routine
   - Chose healthier food and drink options
   - Other: ____________
   - None of the Above

24. Do you plan to continue with the changes you made?
   d. Yes
   e. No
   f. Don’t know

25. Did you share the information from the Fitbit monitor with any of your friends or family members?
   d. Yes
   e. No
   f. Don’t know
26. On average how much time did you spend reading, talking about, or using the Fitbit monitor?
   e. 1-10 minutes
   f. 11-20 minutes
   g. 21-30 minutes
   h. More than 30 minutes

27. How important to you personally was the information provided by the following tools?
   a. Weekly Emails?
   b. Fitbit website?
   c. Fitbit Monitor?
   Not at all A little Somewhat Very much so Completely

28. How much did the information provided by the following tools apply to your life?
   Weekly Emails?
   Fitbit website?
   Fitbit Monitor?
   Not at all A little Somewhat Very much so Completely

29. How much did you trust that the information provided by the following tools was accurate?
   Weekly Emails?
   Fitbit website?
   Fitbit Monitor?
   Not at all A little Somewhat Very much so Completely

Thank you. This last section will now ask you about your overall perceptions of the intervention. Click Next to continue.

**Perceptions of Intervention**

1. Please rate how useful you found the following study components were in motivating you to exercise:

   1  2  3  4  5  6  7  N/A
   Not at all useful Very useful
   a. The Fitbit
   b. Weekly emails
c. Fitbit website
d. Weekly goal setting

2. Please rate the following statements on a scale of 1-5:

I enjoyed participating in this study.
I felt this study was designed for someone like me.
I would recommend this study to another breast cancer survivor.

1 2 3 4 5 6 7
Totally disagree Completely agree

Thank you. You are almost done with your final questionnaire. Please click Next to answer these last questions.

DEMOGRAPHICS:
In general, would you say your health is:

☐ Excellent
☐ Very Good
☐ Good
☐ Fair
☐ Poor

About how much do you weigh, in pounds, without shoes?

_________ pounds

Where did you usually sync your Fitbit? Select all that apply.

☐ Home
☐ Work
☐ Other: ________

Which device(s) did you use to sync your Fitbit? Select all that apply.

☐ Desktop
☐ Laptop
☐ Tablet
☐ Smartphone
☐ Other: ________
You have now finished your final survey. In the next few days you will be receiving an email with a $20.00 gift card to Amazon.com.

If you have any questions, you may contact our study team at stepbystep@unc.edu.

Again, we thank you for your time and participation.
### Supplemental Table 5.1 Participant demographics

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Tailored (n=44)</th>
<th>Targeted (n=46)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (year; mean(SD))</strong></td>
<td>56.5 (7.6)</td>
<td>53.6 (6.9)</td>
<td>0.06</td>
</tr>
<tr>
<td><strong>Race/ethnicity (n (%))</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Hispanic White/ Caucasian</td>
<td>43 (97.7)</td>
<td>44 (95.6)</td>
<td>0.58</td>
</tr>
<tr>
<td>Black/African-American</td>
<td>1 (2.3)</td>
<td>2 (4.3)</td>
<td></td>
</tr>
<tr>
<td><strong>Body Mass Index (kg/m²; mean(SD))</strong></td>
<td>28.1 (4.8)</td>
<td>28.7 (9.7)</td>
<td>0.71</td>
</tr>
<tr>
<td><strong>Marital Status (n (%))</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Married or Living as Married</td>
<td>35 (79.5)</td>
<td>37 (80.4)</td>
<td>0.92</td>
</tr>
<tr>
<td>Single, divorced, widowed, separated</td>
<td>9 (20.5)</td>
<td>9 (19.6)</td>
<td></td>
</tr>
<tr>
<td><strong>Education level (n (%))</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High School Graduate</td>
<td>3 (6.8)</td>
<td>6 (13)</td>
<td>0.60</td>
</tr>
<tr>
<td>Some college/vocational/trade school</td>
<td>12 (27.3)</td>
<td>11 (23.9)</td>
<td></td>
</tr>
<tr>
<td>College graduate</td>
<td>11 (25)</td>
<td>13 (28.3)</td>
<td></td>
</tr>
<tr>
<td>Post-Graduate/Professional</td>
<td>18 (40.9)</td>
<td>16 (34.8)</td>
<td></td>
</tr>
<tr>
<td><strong>Annual Income &gt; $50,000 (n (%))</strong></td>
<td>35 (79.5)</td>
<td>39 (84.8)</td>
<td>0.67</td>
</tr>
<tr>
<td><strong>Employment Status (n (%))</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employed</td>
<td>35 (79.5)</td>
<td>39 (84.8)</td>
<td>0.67</td>
</tr>
<tr>
<td>Unemployed/Retired/Homemaker</td>
<td>8 (18.2)</td>
<td>7 (15.2)</td>
<td></td>
</tr>
<tr>
<td>Missing</td>
<td>1 (2.3)</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td><strong>Age of Diagnosis (years; mean (SD))</strong></td>
<td>50.5 (7.3)</td>
<td>47.9 (6.1)</td>
<td>0.07</td>
</tr>
<tr>
<td><strong>Years Post-diagnosis (years; mean(SD))</strong></td>
<td>4.4 (2.3)</td>
<td>4.1 (1.8)</td>
<td>0.41</td>
</tr>
<tr>
<td>Missing</td>
<td>0 (0)</td>
<td>1 (2.2)</td>
<td></td>
</tr>
<tr>
<td><strong>Cancer Stage at Diagnosis (n (%))</strong></td>
<td></td>
<td></td>
<td>0.61</td>
</tr>
<tr>
<td>0/carcoma in situ</td>
<td>5 (11.4)</td>
<td>8 (17.4)</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>16 (36.4)</td>
<td>18 (39.1)</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>23 (52.3)</td>
<td>20 (43.5)</td>
<td></td>
</tr>
<tr>
<td>Treatment Type (n (%))</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>--------</td>
<td>--------</td>
<td>------</td>
</tr>
<tr>
<td>Surgery</td>
<td>44 (100)</td>
<td>45 (97.8)</td>
<td>0.33</td>
</tr>
<tr>
<td>Chemotherapy</td>
<td>32 (72.8)</td>
<td>28 (60.9)</td>
<td>0.24</td>
</tr>
<tr>
<td>Radiation</td>
<td>30 (68.2)</td>
<td>31 (67.4)</td>
<td>0.94</td>
</tr>
<tr>
<td>Aromatase Inhibitor (yes) (n (%))</td>
<td>10 (21.7)</td>
<td>9 (20.5)</td>
<td>0.88</td>
</tr>
<tr>
<td>Health Rating</td>
<td></td>
<td></td>
<td>0.69</td>
</tr>
<tr>
<td>Excellent</td>
<td>4 (4.3)</td>
<td>2 (4.3)</td>
<td></td>
</tr>
<tr>
<td>Very Good</td>
<td>19 (43.3)</td>
<td>24 (52.2)</td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>18 (40.9)</td>
<td>16 (34.8)</td>
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<tr>
<td>Fair</td>
<td>3 (6.8)</td>
<td>4 (8.7)</td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td></td>
</tr>
</tbody>
</table>
Appendix J continued: Supplemental Tables and Figures
Supplemental Figure 5.1 Difference in average daily steps (by week) between groups (Tailored minus Targeted) for the mixed model.

Model adjusted for time, group, and group by time interaction variables. * = p<0.05, a = p<0.08

Participants per week (Tailored, Targeted): BL: 43, 42; W2: 43, 43; W3: 43, 43; W4: 39, 39; W5: 40, 38; W6: 40, 39; W7: 39, 39; W8: 37, 39; W9: 38, 37; W10: 38, 37; W11: 39, 34; W12: 36, 34; W13: 36, 34; FU: 26, 25
Supplemental Figure 5.2 Number of participants in the tailored and targeted groups who synced/wore their Fitbit for each week of the study.

BL = baseline, F/U = follow-up
**Supplemental Figure 5.3** Change in average daily steps (by week) between groups from baseline for adjusted model.

Step change adjusted for time, group, group by time interaction, and baseline steps.

Participants per week (Tailored, Targeted): **BL**: 43, 42; **W1**: 43, 43; **W2**: 43, 43; **W3**: 39, 39; **W4**: 40, 38; **W5**: 40, 39; **W6**: 39, 39; **W7**: 37, 39; **W8**: 38, 37; **W9**: 38, 37; **W10**: 39, 34; **W11**: 36, 34; **W12**: 36, 34; **FU**: 26, 25
Supplemental Figure 5.4 Trends in average daily steps (by week) below the sample median between the tailored and targeted groups (unadjusted models).
Supplemental Figure 5.5 Trends in average daily steps (by week) above the sample median between the tailored and targeted groups (unadjusted models).
**Supplemental Table 5.2** Difference in Fitbit wear-time.

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Follow-up</th>
<th>Change from BL to FU</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Actual Days of</td>
<td>Between Group</td>
<td>Actual Days of</td>
</tr>
<tr>
<td></td>
<td>Wear (at least</td>
<td>@BL p</td>
<td>Wear (at least</td>
</tr>
<tr>
<td></td>
<td>100 steps) Mean</td>
<td></td>
<td>100 steps) Mean</td>
</tr>
<tr>
<td></td>
<td>(SD)</td>
<td></td>
<td>(SD)</td>
</tr>
<tr>
<td>Tailored</td>
<td>6.18 (1.05)</td>
<td>p=0.69</td>
<td>4.5 (2.72)</td>
</tr>
<tr>
<td>Targeted</td>
<td>6.27 (1.12)</td>
<td></td>
<td>4.05 (3.1)</td>
</tr>
<tr>
<td>Total Sample</td>
<td>6.22 (1.08)</td>
<td></td>
<td>4.28 (2.89)</td>
</tr>
</tbody>
</table>
Supplemental Table 5.3 Change in self-reported weight and BMI by group.

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Baseline Mean (SE)</th>
<th>Follow-up Mean (SE)</th>
<th>Unadj. Mean Change (95% CI)</th>
<th>Time p</th>
<th>Group*Time p</th>
<th>Baseline Mean (SE)</th>
<th>Follow-up Mean (SE)</th>
<th>Adj. Mean Change (95% CI)</th>
<th>Time p</th>
<th>Group*Time p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (kg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tailored</td>
<td>74.38 (2.20)</td>
<td>74.02 (2.20)</td>
<td>-0.35 (-1.23, 0.52)</td>
<td>0.4252</td>
<td></td>
<td>74.07 (2.28)</td>
<td>73.69 (2.28)</td>
<td>-0.39 (-1.28, 0.51)</td>
<td>0.3937</td>
<td>0.6595</td>
</tr>
<tr>
<td>Targeted</td>
<td>75.19 (2.20)</td>
<td>75.09 (2.20)</td>
<td>-0.11 (-0.98, 0.76)</td>
<td>0.8050</td>
<td></td>
<td>75.71 (2.25)</td>
<td>75.60 (2.25)</td>
<td>-0.11 (-0.98, 0.76)</td>
<td>0.8060</td>
<td></td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tailored</td>
<td>27.26 (0.74)</td>
<td>27.13 (0.74)</td>
<td>-0.13 (-0.45, 0.20)</td>
<td>0.4361</td>
<td></td>
<td>27.08 (0.77)</td>
<td>26.94 (0.77)</td>
<td>-0.14 (-0.47, 0.19)</td>
<td>0.3963</td>
<td>0.7174</td>
</tr>
<tr>
<td>Targeted</td>
<td>27.67 (0.74)</td>
<td>27.61 (0.74)</td>
<td>-0.06 (-0.37, 0.26)</td>
<td>0.7226</td>
<td></td>
<td>27.77 (0.76)</td>
<td>27.72 (0.76)</td>
<td>-0.06 (-0.38, 0.26)</td>
<td>0.7238</td>
<td></td>
</tr>
</tbody>
</table>

* Models adjusted for baseline age, time since diagnosis, and stage of breast cancer at diagnosis.
### Supplemental Table 5.4 Comparison of baseline characteristics between completers and non-completers

<table>
<thead>
<tr>
<th></th>
<th>Completers (n=68)</th>
<th>Non-Completers (n=22)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age [mean, SD]</td>
<td>55.7 (7.4)</td>
<td>52.7 (6.7)</td>
<td>0.10</td>
</tr>
<tr>
<td>BMI [mean, SD]</td>
<td>28.8 (5.3)</td>
<td>27.4 (4.6)</td>
<td>0.21</td>
</tr>
<tr>
<td>Years Since Dx</td>
<td>4.2 (2.1)</td>
<td>4.1 (1.9)</td>
<td>0.86</td>
</tr>
<tr>
<td>Cancer Stage (n (%))</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>10 (14.7)</td>
<td>3 (13.6)</td>
<td>0.9</td>
</tr>
<tr>
<td>I</td>
<td>26 (38.2)</td>
<td>8 (36.4)</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>32 (47.1)</td>
<td>11 (50)</td>
<td></td>
</tr>
<tr>
<td>College or higher (n (%))</td>
<td>45 (66.18)</td>
<td>13 (56.1)</td>
<td>0.51</td>
</tr>
<tr>
<td>Married (n (%))</td>
<td>57 (83.8)</td>
<td>15 (68.2)</td>
<td>0.11</td>
</tr>
<tr>
<td>Employed (n (%))</td>
<td>45 (66.2)</td>
<td>15 (68.2)</td>
<td>0.86</td>
</tr>
<tr>
<td>Income &gt;$50K (n (%))</td>
<td>54 (80.6)</td>
<td>20 (90.9)</td>
<td>0.26</td>
</tr>
<tr>
<td>Tamoxifen (yes) (n (%))</td>
<td>15 (22.1)</td>
<td>4 (18.9)</td>
<td>0.70</td>
</tr>
</tbody>
</table>
APPENDIX K. Supplemental Tables for AIM 3

**Supplemental Table 6.1** Evaluation of Autonomy and Perceived Self-Efficacy as Mediators of Change in Step Activity between Baseline and Intervention Midpoint

<table>
<thead>
<tr>
<th>Path</th>
<th>Autonomy</th>
<th>Perceived Self-Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>b(SE)</td>
<td>p</td>
</tr>
<tr>
<td>c</td>
<td>621.40 (648.85)</td>
<td>0.3414</td>
</tr>
<tr>
<td>a</td>
<td>0.02 (0.16)</td>
<td>0.9224</td>
</tr>
<tr>
<td>b</td>
<td>336.75 (466.45)</td>
<td>0.4727</td>
</tr>
<tr>
<td>c'</td>
<td>615.99 (651.06)</td>
<td>0.3473</td>
</tr>
<tr>
<td>Sobel</td>
<td>5.42 (55.89)</td>
<td>0.9228</td>
</tr>
</tbody>
</table>
**Supplemental Table 6.2** Evaluation of autonomy as a potential mediator of change in self-reported physical activity outcomes between baseline and follow-up

<table>
<thead>
<tr>
<th>Path</th>
<th>MVPA (minutes)</th>
<th>Mild PA (minutes)</th>
<th>Total PA (minutes)</th>
<th>Sitting (hours)</th>
<th>Screen (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>b(SE)</td>
<td>p</td>
<td>b(SE)</td>
<td>p</td>
<td>b(SE)</td>
</tr>
<tr>
<td>e</td>
<td>-20.00 (24.17)</td>
<td>0.4105</td>
<td>-6.40 (25.17)</td>
<td>0.7999</td>
<td>-26.40 (37.78)</td>
</tr>
<tr>
<td>a</td>
<td>-0.03 (0.17)</td>
<td>0.8858</td>
<td>-0.03 (0.17)</td>
<td>0.8858</td>
<td>-0.03 (0.17)</td>
</tr>
<tr>
<td>b</td>
<td>35.38 (15.36)</td>
<td>0.0239</td>
<td>16.24 (16.43)</td>
<td>0.3262</td>
<td>51.62 (24.12)</td>
</tr>
<tr>
<td>e'</td>
<td>-19.12 (23.53)</td>
<td>0.4191</td>
<td>-5.99 (25.18)</td>
<td>0.8124</td>
<td>-25.11 (36.95)</td>
</tr>
<tr>
<td>Sobel</td>
<td>-0.88 (6.15)</td>
<td>0.8856</td>
<td>-0.41 (2.85)</td>
<td>0.8866</td>
<td>-1.29 (8.97)</td>
</tr>
</tbody>
</table>

Abbreviations: **MVPA** Moderate to Vigorous Activity, **PA** Physical Activity, **SE** Standard Error
Supplemental Table 6.3 Evaluation of perceived competence as a potential mediator of change in self-reported physical activity outcomes between baseline and follow-up

<table>
<thead>
<tr>
<th>Path</th>
<th>MVPA (minutes) b(SE)</th>
<th>p</th>
<th>Mild PA (minutes) b(SE)</th>
<th>p</th>
<th>Total PA (minutes) b(SE)</th>
<th>p</th>
<th>Sitting (hours) b(SE)</th>
<th>p</th>
<th>Screen (hours) b(SE)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>c</td>
<td>-20.00 (24.17)</td>
<td>0.4105</td>
<td>-6.40 (25.17)</td>
<td>0.7999</td>
<td>-26.40 (37.78)</td>
<td>0.4868</td>
<td>-0.04 (0.22)</td>
<td>0.8644</td>
<td>0.65 (0.32)</td>
<td>0.0426</td>
</tr>
<tr>
<td>a</td>
<td>0.05 (0.34)</td>
<td>0.8833</td>
<td>0.05 (0.34)</td>
<td>0.8833</td>
<td>0.05 (0.34)</td>
<td>0.8833</td>
<td>0.05 (0.34)</td>
<td>0.8833</td>
<td>0.05 (0.34)</td>
<td>0.8833</td>
</tr>
<tr>
<td>b</td>
<td>30.43 (7.34)</td>
<td>&lt;.0001</td>
<td>12.89 (8.32)</td>
<td>0.1257</td>
<td>43.32 (11.69)</td>
<td>0.0004</td>
<td>0.03 (0.07)</td>
<td>0.7344</td>
<td>-0.12 (0.10)</td>
<td>0.2456</td>
</tr>
<tr>
<td>c'</td>
<td>-21.52 (22.00)</td>
<td>0.3309</td>
<td>-7.04 (24.95)</td>
<td>0.7784</td>
<td>-28.57 (35.03)</td>
<td>0.4174</td>
<td>-0.04 (0.22)</td>
<td>0.8607</td>
<td>0.66 (0.31)</td>
<td>0.0403</td>
</tr>
<tr>
<td>Sobel</td>
<td>1.52 (10.34)</td>
<td>0.8830</td>
<td>0.64 (4.39)</td>
<td>0.8834</td>
<td>2.17 (14.71)</td>
<td>0.8830</td>
<td>0.00 (0.01)</td>
<td>0.8924</td>
<td>-0.01 (0.04)</td>
<td>0.8838</td>
</tr>
</tbody>
</table>

Abbreviations: **MVPA** Moderate to Vigorous Activity, **PA** Physical Activity, **SE** Standard Error
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