DAILY PHYSICAL ACTIVITY AND FEAR OF RECURRENCE IN EARLY STAGE BREAST CANCER PATIENTS AND THEIR SPOUSES

by

Lauren Elizabeth McManus

A dissertation submitted to the Faculty of the University of Delaware in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Psychology

Summer 2016

© 2016 Lauren Elizabeth McManus
All Rights Reserved
DAILY PHYSICAL ACTIVITY AND FEAR OF RECURRENCE IN EARLY STAGE BREAST CANCER PATIENTS AND THEIR SPOUSES

by

Lauren Elizabeth McManus

Approved: __________________________________________________________

Robert F. Simons, Ph.D.
Chair of the Department of Psychological and Brain Sciences

Approved: __________________________________________________________

George H. Watson, Ph.D.
Dean of the College of Arts and Sciences

Approved: __________________________________________________________

Ann L. Ardis, Ph.D.
Senior Vice Provost for Graduate and Professional Education
I certify that I have read this dissertation and that in my opinion it meets the academic and professional standard required by the University as a dissertation for the degree of Doctor of Philosophy.

Signed: __________________________________________________________
Jean-Philippe Laurenceau, Ph.D.
Professor in charge of dissertation

I certify that I have read this dissertation and that in my opinion it meets the academic and professional standard required by the University as a dissertation for the degree of Doctor of Philosophy.

Signed: __________________________________________________________
Adele Hayes, Ph.D.
Member of dissertation committee

I certify that I have read this dissertation and that in my opinion it meets the academic and professional standard required by the University as a dissertation for the degree of Doctor of Philosophy.

Signed: __________________________________________________________
Lisa Jaremka, Ph.D.
Member of dissertation committee

I certify that I have read this dissertation and that in my opinion it meets the academic and professional standard required by the University as a dissertation for the degree of Doctor of Philosophy.

Signed: __________________________________________________________
Scott Siegel, Ph.D.
Member of dissertation committee
ACKNOWLEDGMENTS

Jean-Philippe Laurenceau, Ph.D., for his mentorship throughout this project as well as during my progress towards the doctoral degree. I greatly appreciate his willingness to become my mentor following the passing of Dr. Lawrence Cohen in 2012, and for his support following that difficult time. I am also grateful for his efforts towards incorporating my interests into the work of the lab, especially with regards to utilizing accelerometers to collect physical activity data.

Adele Hayes, Ph.D., for serving as a committee member, and for her consistent support throughout my graduate school career. She has been a mentor in both research and clinical work, and I am grateful for the knowledge she has bestowed upon me and the support she has provided over the last six years.

Scott Siegel, Ph.D., from the Helen F. Graham Cancer Center, and Lisa Jaremka, Ph.D., for serving as committee members and providing valuable insights and helpful comments throughout this project.

My professional colleagues and friends for their feedback, support, humor, and understanding, especially from Ariel Williamson. Her support and friendship has been one of the most valuable things I’ve gained during my graduate career.
My parents, Barbara and Joseph Courtright, my brother, Kevin Courtright, my extended family, and my family-in-law, the McManuses and Shores, for their encouragement.

Above all, I grateful for my husband, Andrew McManus, who has provided me with unconditional support, love, humor, encouragement, and guidance in navigating this project and my life since 2007.
# TABLE OF CONTENTS

LIST OF TABLES ........................................................................................................ viii
LIST OF FIGURES ...................................................................................................... ix
ABSTRACT ............................................................................................................... xii

Chapter

1 INTRODUCTION ...................................................................................................... 1

- Defining Fear of Recurrence .............................................................................. 4
- A Conceptualization of Antecedents and Consequences of FOR ...................... 7
- Benefits of Physical Activity Exist in a Social Context ..................................... 11
- Physical Activity has Specific Benefits for Cancer Survivors ......................... 17
- Current State of Objectively Measured Physical Activity ............................... 19
- Health Behaviors and Fear of Recurrence ..................................................... 21
- The Current Study ............................................................................................ 23

   Aim 1: Establish Links Between Fear of Recurrence and Physical Activity ....................................................... 24
   Aim 2: Evaluate the Influence of Each Patient and Spouse's FOR and PA on their Partner's FOR and PA .............. 25

2 METHOD ............................................................................................................. 27

- Overview .......................................................................................................... 27
- Participants ....................................................................................................... 27
- Procedure .......................................................................................................... 33
- Daily Measures ................................................................................................. 34

   Fear of Recurrence ..................................................................................... 34
   Physical Activity and Sedentary Behavior ................................................. 36
   Subjective Sleep Quality ............................................................................ 39

Control Variables .............................................................................................. 39

- Body Mass Index ........................................................................................ 39
- Radiation Treatment ................................................................................. 40
- Chemotherapy Treatment ....................................................................... 40
- Stage of Cancer ........................................................................................... 40
- Employment Status ..................................................................................... 40

Data Analytic Approach ................................................................................... 40
3 RESULTS................................................................................................................................. 43

Preliminary Analyses............................................................................................................ 43
Primary Analyses.................................................................................................................. 46

Aim 1: Linkages Between FOR and PA ............................................................................... 46
Aim 2: The Influence of Each Patient and Spouse's FOR and PA on their Partner's FOR and PA ................................................................. 52

4 DISCUSSION....................................................................................................................... 55

Study Strengths and Implications .................................................................................... 61
Limitations and Future Directions .................................................................................... 62
Concluding Comments ...................................................................................................... 68

REFERENCES...................................................................................................................... 70

Appendix

A UNIVERSITY OF DELAWARE INSTITUTIONAL REVIEW BOARD APPROVAL .................................................................................. 80
B DATA FIGURES................................................................................................................ 81
LIST OF TABLES

Table 1  Summary of Surgery Types for Patients........................................29
Table 2  FOR Items Adapted from the Fear of Cancer Recurrence Inventory (Simard & Savard, 2007) .................................................................35
Table 3  Means, Standard Deviations, and Intraclass Correlations for Major Study Variables.................................................................45
Table 4  Within-Person Correlations between all Study Variables for Patient and Spouse.................................................................45
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1</td>
<td>Model of FOR from Lee-Jones, Humphris, Dixon, and Hatcher (1997)</td>
<td>11</td>
</tr>
<tr>
<td>Figure 2</td>
<td>Timeline of R21 Study of Fear of Recurrence in Breast Cancer Patients and Their Spouses</td>
<td>30</td>
</tr>
<tr>
<td>Figure 3</td>
<td>Study Recruitment Throughout Full Timeline of R21 Project</td>
<td>32</td>
</tr>
<tr>
<td>Figure 4</td>
<td>Actor-Partner Interdependence Model for Concurrent Links with FOR Predicting PA</td>
<td>81</td>
</tr>
<tr>
<td>Figure 5</td>
<td>Actor-Partner Interdependence Model for Within-Person Concurrent Links with FOR Predicting MVPA with Results</td>
<td>82</td>
</tr>
<tr>
<td>Figure 6</td>
<td>Actor-Partner Interdependence Model for Between-Person Concurrent Links with FOR Predicting MVPA with Results</td>
<td>83</td>
</tr>
<tr>
<td>Figure 7</td>
<td>Actor-Partner Interdependence Model for Within-Person Concurrent Links with FOR Predicting Nonsedentary Time with Results</td>
<td>84</td>
</tr>
<tr>
<td>Figure 8</td>
<td>Actor-Partner Interdependence Model for Between-Person Concurrent Links with FOR Predicting Nonsedentary Time with Results</td>
<td>85</td>
</tr>
<tr>
<td>Figure 9</td>
<td>Actor-Partner Interdependence Model for Within-Person Concurrent Links with FOR Predicting Sedentary Time with Results</td>
<td>86</td>
</tr>
<tr>
<td>Figure 10</td>
<td>Actor-Partner Interdependence Model for Between-Person Concurrent Links with FOR Predicting Sedentary Time with Results</td>
<td>87</td>
</tr>
<tr>
<td>Figure 11</td>
<td>Actor-Partner Interdependence Model for Concurrent Links with PA Predicting FOR</td>
<td>88</td>
</tr>
<tr>
<td>Figure 12</td>
<td>Actor-Partner Interdependence Model for Within-Person Concurrent Links with MVPA Predicting FOR with Results</td>
<td>89</td>
</tr>
<tr>
<td>Figure 13</td>
<td>Actor-Partner Interdependence Model for Between-Person Concurrent Links with MVPA Predicting FOR with Results</td>
<td>90</td>
</tr>
<tr>
<td>Figure 14</td>
<td>Actor-Partner Interdependence Model for Within-Person Concurrent Links with Nonsedentary Time Predicting FOR with Results</td>
<td>91</td>
</tr>
</tbody>
</table>
Figure 15  Actor-Partner Interdependence Model for Between-Person Concurrent Links with Nonsedentary Time Predicting FOR with Results ........................92

Figure 16  Actor-Partner Interdependence Model for Within-Person Concurrent Links with Sedentary Time Predicting FOR with Results ........................93

Figure 17  Actor-Partner Interdependence Model for Between-Person Concurrent Links with Sedentary Time Predicting FOR with Results ..............................94

Figure 18  Actor-Partner Interdependence Model with FOR Predicting Next Day PA ........................................................................................................95

Figure 19  Actor-Partner Interdependence Model for Within-Person Links with FOR Predicting Next Day MVPA with Results ............................................96

Figure 20  Actor-Partner Interdependence Model for Between-Person Links with FOR Predicting Next Day MVPA with Results ............................................97

Figure 21  Actor-Partner Interdependence Model for Within-Person Links with FOR Predicting Next Day Nonsedentary Time with Results .........................98

Figure 22  Actor-Partner Interdependence Model for Between-Person Links with FOR Predicting Next Day Nonsedentary Time with Results .........................99

Figure 23  Actor-Partner Interdependence Model for Within-Person Links with FOR Predicting Next Day Sedentary Time with Results ............................100

Figure 24  Actor-Partner Interdependence Model for Between-Person Links with FOR Predicting Next Day Sedentary Time with Results ............................101

Figure 25  Actor-Partner Interdependence Model with PA Predicting Next Day FOR ........................................................................................................102

Figure 26  Actor-Partner Interdependence Model for Within-Person Links with MVPA Predicting Next Day FOR with Results .................................103

Figure 27  Actor-Partner Interdependence Model for Between-Person Links with MVPA Predicting Next Day FOR with Results .................................104

Figure 28  Actor-Partner Interdependence Model for Within-Person Links with Nonsedentary Time Predicting Next Day FOR with Results .........................105
Figure 29  Actor-Partner Interdependence Model for Between-Person Links with Nonsedentary Time Predicting Next Day FOR with Results ……………..106

Figure 30  Actor-Partner Interdependence Model for Within-Person Links with Sedentary Time Predicting Next Day FOR with Results …………………107

Figure 31  Actor-Partner Interdependence Model for Between-Person Links with Sedentary Time Predicting Next Day FOR with Results …………………108
ABSTRACT

Physical activity (PA) represents a primary and secondary modifiable risk factor for chronic diseases such as cancer, a disease with both physical and mental health implications. In particular, PA has been shown to have many beneficial effects for cancer survivors, including reduced risk of cancer recurrence and improved well-being. Fear of recurrence (FOR) is often a top concern for cancer patients and their families, and has been associated with distress and disruptions in daily functioning, including health behaviors. An important question yet to be investigated is whether there is a relationship between FOR and PA in both patients and their spouses/partners who are coping with breast cancer. The present study attempted to address this gap in the literature by examining the directionality of the relationship between daily reports of FOR and daily objectively measured PA in both breast cancer survivors and their partners. Using a daily-diary design, patients and spouses each independently reported on their daily experience of FOR for 21 consecutive days as well as wore an accelerometer to measure PA. At the between-persons level, results indicated that patients and spouses who reported higher average FOR across the diary period, also engaged in less moderate-vigorous PA and more sedentary behavior. Patients who engaged in more PA across the diary period reported less average FOR. At a within-person level, results revealed that, for spouses, increased FOR on one day predicted more PA the next day. For patients, increased PA on one day predicted increased FOR the next day. This work has the potential to influence efforts towards developing effective interventions to help patients and spouses engage in
regular PA by understanding the dynamic interplay between FOR and PA within the context of intimate relationships.
Chapter 1

INTRODUCTION

Currently there are close to 14 million cancer survivors in the United States, with nearly half of the population of female cancer survivors being breast cancer survivors (Siegel et al., 2012). As cancer treatments continue to improve, the population of cancer survivors who are left coping with changes in their post-treatment lives continues to grow. One of the top concerns often cited by survivors is fear of cancer recurrence (FOR; Beckjord et al., 2014; Fiszer, Dolbeault, Sultan, & Bredart, 2014). FOR is generally defined as “fear that cancer could return or progress in the same place or in another part of the body” (p.361, Simard, Savard, & Ivers, 2010; Simard et al., 2013). Further, both patients and their significant others (e.g., spouse/partners, other family members, caregivers) are impacted by a diagnosis of cancer, especially with regard to the experience of FOR (e.g., Kim, Carver, Spillers, Love-Ghaffari, & Kaw, 2011). Therefore, it is important to understand and address the unique needs of this population of couples coping with breast cancer and related FOR.

Health behaviors, such as diet, exercise, and tobacco use, represent some of the important modifiable lifestyle factors that can impact a cancer survivor’s physical and mental health. Few survivors are meeting the recommendations provided for these behaviors, particularly in the areas of diet and physical activity (Blanchard, Courneya,
Cancer patients meeting recommendations for healthy behaviors may experience benefits in other aspects of quality of life, such as FOR. Physical activity (PA) may be a health behavior of particular importance. For instance, in a study examining several different health behaviors, PA was most strongly related to improvements in quality of life (Blanchard et al., 2004). A main goal of the current study is to understand further how health behaviors and psychosocial variables interact to impact the daily lives of breast cancer patients and their partners.

Guidelines for health behaviors such as diet and exercise are often provided as a general “prescription” to cancer survivors, as these behaviors have the potential to reduce an individual’s risk of cancer recurrence (Warburton, Nicol, & Bredin, 2006). However, behaviors such as PA may also serve as an adaptive coping strategy for cancer survivors and their partners. Specifically, Courneya and Friedenreich (2007) discussed the role of PA across the entire cancer control continuum, with PA aiding in treatment effectiveness, coping, recovery, and health promotion through the treatment phase and into the survivorship phase. As PA has been shown to have both physical as well as psychological benefits, it serves as a potential “dual promoter” of physical and psychological well-being for survivors and their significant others.

There is much evidence to support the existence of a concurrent link between PA and mood. Studies have linked PA to reductions in symptoms of depression and anxiety and to enhancements in mood states (e.g., Byrne & Bryne, 1993; Teychenne,
Linkages also exist between FOR and general psychological distress (Diemling et al., 2006; Kim et al., 2011; Zhao, Portier, Stein, Baker, & Smith, 2009). It is important to point out that FOR has been found to be distinct from general distress and anxious and depressed mood states (Hodges & Humphris, 2009; Simard et al., 2013; Simard, Savard, & Ivers, 2010), thus assuming that the relationship between PA and FOR would be the same as other mood states is premature. FOR’s relation to aspects of emotions and anxiety does indicate the potential for PA to demonstrate salubrious effects on FOR. However, based on available theoretical models conceptualizing the processes that contribute to outcomes such as FOR, FOR may also serve as a predictor of future PA. Therefore, there is reason to believe that the relationship between PA and FOR is reciprocal in nature. There has been little work examining links between FOR and some health behaviors, and to our knowledge no studies specifically have examined the putative link between PA and FOR.

The purpose of this study is to (1) examine the concurrent link between FOR and PA levels, (2) clarify what the temporal nature of this relationship may be, and (3) explore how these variables relate within the context of an intimate relationship. Importantly, this work has potential implications for interventions focused on promoting regular PA by understanding the nature of the links between FOR and PA in couples coping with a relationship member’s illness.
Defining Fear of Recurrence

The construct of fear of recurrence (FOR) is of particular interest to the present study, as it is relevant for the breast cancer population from which the data for this study will be gathered, experienced to some degree by survivors of all cancer types, and related to well-being. When surveyed, FOR is often one of the primary ongoing concerns of cancer patients (Costanzo et al., 2007; Hodges & Humphris, 2009). FOR, or the concern that cancer could return, (Simard, Savard, & Ivers, 2010; Simard et al., 2013), and is not necessarily related to a patient’s actual recurrence risk. Elevated and/or clinically significant levels of FOR have been shown to be related to decreases in QOL for survivors and difficulties with health behavior change (Hawkins et al, 2009; Park & Gaffey, 2007; Simard et al., 2013; Van Liew, Christensen, Howren, Karnell, & Funk, 2013).

FOR has been conceptualized as a multidimensional construct involving emotional (e.g., anxiety, fear) and cognitive (e.g., worry, preoccupation, and intrusive thoughts) components that interact to influence an individual’s behavior (Lee-Jones, et al. 1997; Moser et al., 2007; Park, Cho, Blank, & Wortmann, 2012). Park et al. (2012) provided empirical support for this multidimensional model by demonstrating that the emotional and cognitive aspects had independent predictors as well as consequences.

While FOR is often endorsed as a top concern among cancer survivors, there still remains no consensus on what constitutes clinically significant levels of FOR. However, FOR does appear to occur on a continuum, ranging from normal levels of
vigilance of cancer return to excessive checking and psychological distress. Simard et al. (2013) conducted a review of the FOR literature and found that an average of 73% of cancer survivors reported some degree of FOR, with an average of 49% reporting moderate to high levels. This same review found that 20%-79% of survivors listed FOR as an unmet need within their care. Variables often associated with higher levels of FOR include younger age at diagnosis, lower socioeconomic status, severity of physical symptoms, increased psychological distress, and decreased quality of life, although more studies are needed to determine the direction of effects for these variables. FOR is only moderately correlated (e.g., $r = .30-.60$) with increased distress, depression, anxiety, and intrusion/avoidance (Simard et al., 2013). Additionally, Zhao et al. (2009) completed a factor analysis of a FOR measure in which they identified four distinct factors among patients. These four factors were physical distress, emotional distress, employment/financial problems, and FOR, suggesting that FOR should be considered to be independent of general emotional distress that patients or their partners may report.

It is important to remember that cancer is not experienced by the patient alone, and instead has come to be conceptualized as a “we-disease,” in which both the patient and partner are impacted by the diagnosis and treatment of cancer (Kayser, Watson, & Andrade, 2007). It has been demonstrated during the course of cancer treatment that there is significant fear and anxiety in both patients and partners (Costanzo et al., 2007). In fact, partners have demonstrated comparable, and at times greater, levels of
FOR as compared to cancer patients themselves (e.g., Kim et al., 2011; Mellon, Kershaw, Northouse, & Freeman-Gibb, 2007; Simard et al., 2013). Relationships, especially those with intimate partners, can be an important support system for those diagnosed with cancer, as couples work together to cope with the disease. However, this support system can influence the experience of FOR in each partner in both positive and negative ways. Studies have shown that there is significant concordance between the experience of depressive symptoms, well-being, and quality of life among couples such that couples tended to report similar levels of the variables in question (Meyler, Stimpson, & Peek, 2007; Molloy, Stamatakis, Randall, & 2009). Concordance refers to both the level of correlation between indicators of well-being at the within-couple level, as well as the fact that the well-being of one spouse tends to influence the well-being of the other.

As an illustration of the concordance of FOR in couples, Mellon, Kershaw, Northouse, and Freeman-Gibb (2007) used the Actor-Partner Interdependence Model (Cook & Kenny, 2005) to demonstrate that FOR experienced by one partner influenced the level of FOR in the other partner, such that when one partner’s FOR increased, so did the other partner’s FOR. Additionally, Wells-DiGregorio et al. (2012) reported that caregivers of cancer patients experienced a reduction in physical health and immune function, and that this relationship was associated more strongly with the caregiver’s subjective experience of cancer-related stress than the patient’s actual recurrence risk.
Taking into account the relational context of FOR is critical, as supportive relationships have been linked to reductions in FOR (Bergman, Gore, Saigai, Kwan, & Litwin, 2009). Northouse (1981) has found that women with fewer significant others exhibited higher FOR levels, and proposed the possibility that support from significant others may help the patient manage their fears. Additionally, studies have linked one partner’s FOR to worse outcomes in his/her partner (Hodges & Humphris, 2009; Kim et al., 2011), suggesting that the experience of FOR in both the patient and partner has important impacts on the functioning of each individual. These findings highlight the importance of considering cancer, and FOR in particular, within the context of an intimate relationship, in order to better understand the influence that each partner has on the other’s well-being.

A Conceptualization of Antecedents and Consequences of FOR

Leventhal’s Common Sense Model of Self-Regulation of Health and Illness (Leventhal, Diefenback, & Leventhal, 1992) and Lee-Jones, Humphris, Dixon, and Hatcher’s (1997) adaptation of the model to FOR provide a theoretical framework in which to conceptualize the potential linkages between FOR and PA. Leventhal’s (1992) Common Sense Model states that self-regulation of thoughts, feelings, and behaviors is a function of an individual’s representation of health threats (i.e., an illness representation), the targets for ongoing coping set by the representation, the procedures to regulate these targets, and appraisal of the coping outcomes. Internal and external stimuli are continually interpreted based on an individual’s illness
representation, or beliefs about their illness. Whether or not an individual’s illness representation is accurate will influence how he/she reacts to stimuli. Furthermore, cognitive and emotional processing form an integrated self-regulation system. For example, if a person experiences a physical symptom such as feeling pain near their surgical site (i.e., an internal stimuli) they may have the thought “the cancer is back,” based on their illness representation of breast cancer (e.g., “everyone dies from cancer”). The representation may cause them to feel anxious or fearful. This leads to coping responses being chosen, which may be maladaptive if the illness representation is also maladaptive. For example, an individual may choose to avoid doing certain activities, such as exercise, which could cause them to feel somatic sensations that are unpleasant.

Lee-Jones and colleagues (1997) applied Leventhal’s Common Sense Model to a conceptualization of the antecedents and consequences of FOR. They use this theoretical framework to understand why different people may be more or less concerned with the possibility of recurrence based on differing representations of the illness. The model states that internal and external cues serve as antecedents to FOR. These antecedents trigger cognitions and emotions related to FOR. Their model of FOR indicates that an individual’s FOR will vary based on their illness representation, and that this can have positive or negative effects on behavior depending on the degree to which it is experienced. An individual with an inaccurate representation of breast cancer may be more likely to interpret stimuli in a threatened manner, therefore
increasing their experience of FOR. The model states that maladaptive emotional and
cognitive reactions to the disease may lead to high risk behavior such as smoking or
alcohol use. Individuals may change their behavior, such as avoiding certain foods or
activities, if they fear it will contribute to recurrence.

For this proposed study, we are conceptualizing changes in PA as a class of
possible behavioral responses. This conceptualization is based on the anxiety literature
and the connections that have been established between anxiety sensitivity (i.e., the
tendency to interpret somatic signs as dangerous) and reduced exercise frequency,
which suggests that individuals who experience anxiety avoid the physiological
sensations associated with anxiety (Anderson & Shivakumar, 2013; Sawchuck &
Olatunji, 2011). As applied to FOR, the experience of having concerns or worries
about the cancer returning has some overlap with symptoms of anxiety. Those who
have a tendency to misinterpret or be vigilant to somatic sensations as signs that the
cancer might be returning, may reduce PA because it draws attention to somatic
symptoms such as shortness of breath, muscle pain and cramping, which can be
interpreted as dangerous. For some individuals, PA may serve as a way of coping with
concerns or stimuli that trigger threat for survivors. PA may play a regulatory
function. For instance, if an individual is feeling distressed, PA can reduce their
distress to a more manageable level. It is possible that the influence of FOR on PA
may reflect the stress-performance continuum, such that at either extreme of the
continuum FOR can have a negative impact on PA levels, but when experienced at
moderate levels it can serve as a motivating factor. The Lee-Jones et al. (1997) model maps out antecedents that lead to the experience of FOR, which in turn leads to behaviors and psychological consequences (Figure 1). The present study focused on the second half of the model, which focuses on the consequences of FOR.
Benefits of Physical Activity Exist in a Social Context

PA has been shown to aid in both the primary (i.e., reducing an individual’s risk of developing a chronic disease) and secondary (i.e., benefits that individuals receive even after a diagnosis) prevention of chronic diseases such as cardiovascular disease, obesity, diabetes, cancer, hypertension, and depression (Warburton, Nicol, &
Bredin, 2006). Unfortunately, more than 60% of adults in the United States do not engage in the recommended amount of PA (i.e., 30 minutes per day of moderate intensity PA on at least 5 days per week; World Health Organization, 2014). Sedentary behavior is one of, if not the most, prevalent modifiable risk factors for chronic disease (Warburton et al., 2006). PA pertains not only to structured exercise, but also to the amount of time spent in which one is not sedentary. That is, PA can be accrued in job settings and through leisure activities, in addition to more structured bouts of exercise such as going to the gym, walking, or running. While PA can reduce an individual’s risk of developing a chronic disease, there are additional benefits once a diagnosis has been made in terms of overall health and well-being. For example, PA is recommended for cardiovascular patients in order to ameliorate or reverse their disease process (Warburton et al., 2006). Exercise interventions for patients with diabetes have also been shown to be beneficial in improving glucose levels (Warburton et al., 2006).

In addition to physical health improvements, PA has been associated with improvements in psychosocial outcomes such as mood and general well-being in both chronically ill and healthy populations (Salovey, Rothman, & Steward, 2000). Those who do not engage in PA have been shown to be twice as likely to exhibit symptoms of depression and anxiety (DeMello et al., 2013). Although a dose-response relationship appears to exist between PA and improvements in moods, even low doses
of PA have been shown to be protective against depression (Teychenne, Ball, & Salmon, 2008).

Recent studies have expanded upon the consistent correlations between PA and mood by investigating the directionality and temporal nature of the relationship between these variables. These studies have demonstrated that a bi-directional relationship exists between mood and PA in both healthy and chronically ill populations (Carols, Coit, Young, & Berger, 2007; DaSilva et al., 2012). Specifically, Carols et al. (2007) found in an obese population that mood in the morning predicted whether or not an individual engaged in PA, that greater exercise intensity was then related to greater mood enhancement, and that these improvements for mood lasted for at least two to four hours after finishing exercise. Additionally, studies have demonstrated that acute bouts of exercise can result in acute changes in biological risk factors for chronic disease such as decreases in blood pressure and improved insulin levels (Warburton, Nicol, & Bredin, 2006). Taken together this work indicates that PA can function both as a means of emotion regulation and as a means of health promotion on a day-to-day basis. The connection between PA and well-being is an important one, as both independently play a role in the prevention and management of chronic diseases. Understanding how these two factors influence each other is beneficial when considering how interventions can improve the management of chronic diseases.
Although specific theories for the connection between PA and well-being are limited, there are multiple proposed mechanisms for PA’s influence on mood. These proposed mechanisms involve both biological pathways (e.g., beta-endorphins, endogenous opioids, inflammatory markers) as well as psychological processes (e.g., increased sense of achievement, self-efficacy, and distraction) (Anderson & Shivakumar, 2013; Sawchuck & Olatunji, 2011; Warburton, Nicol, & Bredin, 2006). However, more work is needed to elucidate the relationship between the biological and psychological pathways that underlie the relationship between PA and well-being.

In addition to considering individual biological factors that influence PA, it is also necessary to consider other individual and contextual factors. Individual, environmental, and social factors interact to determine one’s level of PA. Of particular interest to the current study is how PA may be impacted by the context of a romantic relationship. Research suggests that being in a committed romantic relationship has a definite impact on physical health.

Various studies have summarized the health benefits of marriage, including healthier behaviors like improved diet and decreased smoking (Burman & Margolin, 1992; DiMatteo, 2004; Gallant, 2003). Studies have shown that intimate relationships impact illness processes through the indirect effects of the relationship on health behaviors (Kiecolt-Glaser & Newton, 2001). That is, being in a relationship impacts couples’ behaviors such as diet and PA, and these behaviors in turn impact the health and well-being of each partner. Molloy et al. (2009) found that health behaviors
accounted for 33% and 21% of the change in hazard ratios for cardiovascular mortality in divorced/separated/unmarried men and women, respectively. Stated otherwise, risks increased for separated/divorced/unmarried individuals due to poorer health behaviors. Along with the concordance of mental health as mentioned previously, there is substantial evidence that significant concordance exists between spouses’ physical health statuses. The most common health behaviors reported in concordance studies are diet, smoking, alcohol, and other drug use (Meyler, Stimpson, & Peek, 2007).

Interdependence theory has been proposed to explain the concordant relationship between spousal health behaviors, including PA (Lewis et al., 2006; Li, Cardinal, & Acock, 2013). This approach takes into account the thoughts, feelings, and behaviors of both members of the dyad and the fact that they occur in both an interpersonal and intrapersonal context (Kelley et al., 1983). That is to say, each partner can influence their own outcomes, but due to the intimate nature of their relationship, may also influence their partner’s outcomes as well (and vice versa). Specific to health behaviors, interdependence theory suggests that couples may view a health threat for one partner as a shared threat where they may engage in communal coping strategies, such as PA (Lewis et al., 2005).

Multiple studies have examined interdependence theory in relation to health behaviors within couples. For example, Li, Cardinal, and Acock (2013) examined the extent to which a person’s PA level was influenced by their partner’s PA level. Using actor/partner analyses (Cook & Kenny, 2005) of self-reported PA in a longitudinal
study, they found that PA trajectories (i.e., stable active, adopters, relapsers, and stable sedentary) were predicted by their spouses’ trajectory category. When faced with a health threat, such as cancer, an interdependent couple may look to cope with this threat as a unit, thus impacting each other’s health behaviors. A study by Satariano, Haight, and Tager (2002) found that PA for an individual was best predicted by their spouse’s PA. Additionally, Ayotte, Margrett, and Patrick (2013) used dyadic analyses to demonstrate partner effects on PA, showing that characteristics of one spouse directly and indirectly influenced the PA levels of the other spouse. Khan et al. (2013) conducted a daily diary study of diabetes patients and their partners and found that spousal support was positively associated with PA on a daily basis. Furthermore, their results showed that these effects lasted into the next day. Most relevant to the current study is work by Martire et al. (2012), who used daily diaries and accelerometers to demonstrate that spouses’ daily PA levels were concurrently associated with patients’ increases in moderate PA in a sample of knee osteoarthritis patients and their spouses.

Partners may encourage or reinforce healthy behaviors, join in with the partner in behaviors, or model positive health behaviors. At the same time, partners could also discourage or undermine involvement in healthy behaviors through poor modeling, reinforce avoidance or poor coping, or engage in non-motivating or unhealthy behaviors. As interventions that target couples for behavior change have had mixed results, Lewis et al. (2006) note the importance of understanding how couple members influence health behaviors in order to develop more effective interventions targeted at
the couple level. Due to methodological limitations in the studies presented above (i.e., lack of intensive longitudinal designs and/or objective measures), further research is still needed to understand the dynamic between intimate partners’ PA-related health behaviors.

**Physical Activity has Specific Benefits for Cancer Survivors**

Physical activity has significant connections with chronic diseases. While PA and its potential beneficial effects are most often associated with cardiovascular disease prevention and treatment, there is an extensive literature on the role of PA in the primary prevention of cancer (Physical Activities Guidelines Advisory Committee, 2008; Warburton, Nicol, & Bredin, 2006). Furthermore, PA has been associated with reductions in the risk of death from cancer for breast and colon cancers (Holmes, Chen, Feskanich, Kroenke, & Colditz, 2005; Irwin, Smith, & McTiernan, 2008; Meyerhardt et al., 2006). A dose-response relationship appears to exist between the intensity level of PA and the physical health benefits accrued from that activity on cancer risk reduction. Specifically, moderate PA (e.g., walking at a brisk pace, pushing a lawn mower, waiting tables), has been associated with greater benefits in the reduction of cancer risk, in both healthy populations and those with established cancer diagnoses, over less intense forms of PA (Warburton et al., 2006). However, overall lifestyle activity appears to be important as well, suggesting that any reductions in sedentary behaviors may provide beneficial reductions in risk. There are several proposed biological mechanisms for the benefit accrued from exercise, most notably
reductions in systemic inflammation. Chronic inflammation is associated with most of the chronic diseases for which exercise has demonstrated benefits. Therefore, regulation of inflammatory markers, such as C-reactive protein, may be a key mechanism between exercise and reduction in cancer risk (Warburton et al., 2006).

While PA has been demonstrated to reduce the risk of developing cancer, it is also linked to reductions in mortality from cancer or other causes in patients once a cancer diagnosis has been made. Specific to breast cancer, a significant amount of research has been conducted on breast cancer patients and PA. Overall, engaging in PA after a diagnosis of breast cancer is associated with decreased risk of recurrence of breast cancer (Schmitz et al., 2010). Holick et al. (2008) conducted a large prospective study of women diagnosed with breast cancer and found that women who engaged in greater levels of activity following their diagnosis had significant reductions in mortality overall (i.e., from all causes) and mortality from breast cancer in particular. Similarly, Irwin et al. (2008) conducted a prospective observational study of 933 participants from 1995-2004 and found that women who increased their PA post-diagnosis had a 45% lower risk of death, whereas women who decreased their PA had a four-fold greater risk of death than women whose PA level did not change post-diagnosis.

In addition to reductions in risk following a diagnosis, PA has also been connected to improvements in overall well-being in breast cancer survivors. For example, Schmitz et al. (2010) reviewed the safety and efficacy of randomized
controlled trials of exercise programs for breast cancer patients following treatment completion. Among the variables assessed in this review were quality of life (QOL), depression, and anxiety. Twelve of the 18 studies reviewed cited evidence for improvements in QOL following exercise intervention. Of the seven studies looking at depression, results were mixed, and of the four studies looking at anxiety, all but one reported improvements in anxiety symptoms compared to controls.

As stated earlier, further research is needed to understand more fully the importance of PA after a cancer diagnosis as well as the psychosocial channels through which it operates. Cancer-specific psychosocial variables such as FOR may provide one avenue through which benefits of PA are realized, and the relationship between these variables may be bidirectional. Based on Lee-Jones et al.’s (1997) model, FOR is an important aspect of cancer that may impact behaviors, and these behaviors in turn may influence the experience of FOR. Furthermore, research on the psychosocial factors associated with health behaviors like PA after cancer diagnoses is limited, and restricted to cross-sectional measures that do not investigate into daily processes that may impact these variables.

**Current State of Objectively Measured Physical Activity**

In recent years the trend towards collecting objectively measured PA has grown. Accurate collection of PA data is important for several reasons, including the need to carefully examine dose–response relations between PA, sedentary behavior, and various health outcomes. In addition, objective data are useful in determining
levels and trends in PA and sedentary behavior in studies of “free-living” individuals, or those who engage in PA in daily life (Hildebrand, van Hees, Hansen, & Ekelund, 2014).

Accelerometry is currently the most commonly used objective measurement of PA. Traditionally accelerometers are worn at the hip in order to collect accurate PA data. Recent research has investigated the increased reliability of wrist worn accelerometers for the measurement of PA. There are multiple potential advantages to using a wrist versus a hip placement of the devices, most notably the potential for increase in long-term compliance of wearing the devices (Hildebrand, et al., 2014; van Hees et al., 2011). In addition, wrist placement allows for the examination of lower intensity PA for activities utilizing arm movements versus leg movements (i.e., household chores). Other objective data can also be collected utilizing the same location, namely sleep behaviors, which may provide increased richness to data sets. The 2011-2014 National Health and Nutrition Examination Survey (NHANES) study adjusted its protocol to having participants use a wrist-mounted Actigraph device to simultaneously collect PA and sleep behaviors over a 7-day period, marking the largest data collection of wrist-worn PA to date.

However, limitations exist for the use of wrist worn accelerometers to collect PA data. Namely, research is still being conducted on the reliability of various techniques for scoring the raw data collected from the devices. Promising results have been found using laboratory protocols in which participants engage in specific
activities such as walking and running on a treadmill, and standing, sitting, and laying down (Hildebrand et al., 2014, Staudenmayer et al., 2015). These studies have reported that wrist worn accelerometers appear reliable for overall measurements of PA, but may not be as accurate at determining intensity thresholds (Hildebrand et al., 2014, Rosenberger et al., 2013). Research regarding the reliability of wrist worn accelerometers and PA conducted in daily life are still limited. For the purposes of the current study, wrist worn accelerometers will be worn in order to increase compliance amongst study participants, allow for the collection of sleep data, and to add to the growing literature base utilizing PA data collected using the wrist placement.

**Health Behaviors and Fear of Recurrence**

Elevated levels of FOR have been shown to be related to well-being for survivors and difficulties with health behavior change, with some contradictory results (Hawkins et al., 2009; Park & Gaffey, 2007; Van Liew, Christensen, Howren, Karnell, & Funk, 2013). When experienced at lower intensity levels, FOR has been conceptualized as a potential motivating factor for adaptive behavioral changes. For example, Hawkins et al. (2009) found FOR to be a predictor of positive behavior change across a range of health behaviors. However, a cross-sectional sample of head and neck cancer survivors found that increased levels of FOR were associated with continued use of tobacco, a major health behavior risk factor for this population (Van Liew et al., 2013). Therefore, as illustrated in the Lee-Jones et al. (1997) model, FOR could serve as either a motivating factor for engaging in healthy behaviors, or as a
barrier depending on the individual and the degree of FOR experienced. FOR in relation to health behaviors thus may be experienced in a similar manner as the stress-performance curve, where there exists an optimal level of FOR to assist in motivation to engage in healthy behaviors, but too much or a lack of FOR results in a negative impact on these factors.

Relatively little work has been done to explore the relationship between FOR and health behaviors, specifically PA. Studies that have explored the relationship between FOR and health behaviors have been limited by their use of cross-sectional self-report measures of behaviors, as well as a lack of focus on PA. These cross-sectional studies have typically looked at behavior change following a diagnosis, as opposed to evaluating the relationship between FOR and PA on a day-to-day basis to understand the dynamic between these variables as they unfold in real life. With the advances in the use of objective assessment of PA, an examination of the temporal nature of these variables could also provide important insights. Furthermore, studies have not considered the context (e.g., romantic relationships) in which these behaviors are occur, making it difficult to determine whether or not the context matters. Park and Gaffey (2007) noted that the “trend in health behavior intervention is development of focused therapies that are tailored to the particular individual and his or her specific needs, vulnerabilities, and strengths” (p. 116). In order to better inform the development of these individualized therapies, more work needs to be done to
understand the within-person relationships between FOR and PA, as well as how these variables interrelate within the context of an intimate relationship.

**The Current Study**

In summary, there is an extensive literature linking PA to physical health benefits for cancer survivors, most notably in terms of lowering an individual’s risk of actual cancer recurrence. However, PA has also been linked to improvements in psychosocial outcomes in cancer survivors. We sought to expand the literature on PA and cancer by focusing on FOR, a cancer-specific psychosocial variable that represents a top concern for patients and their significant others. We also made use of an intensive longitudinal design we hoped would provide important insights into the ways that FOR impacts cancer survivors’ day-to-day activities. While some connections between FOR and health behaviors have been established, little work has focused explicitly on the associations between FOR and PA in particular. Furthermore, no studies examining these variables have used intensive longitudinal methods combined with objective measures of PA. Intensive longitudinal methods allow for the examination of within-person processes as well as the examination of the temporal relationships between variables. The primary goal of the current study was to examine whether there was a concurrent link between daily FOR and PA, and if this link was established, to assess the temporal nature of the relationship between PA and fear of recurrence. A theoretical argument for why a bidirectional relationship may exist between FOR and PA can be taken from the Lee-Jones et al.’s (1997) adaptation of the
Common Sense Model, such that if a person is controlling what they can control in terms of preventing their recurrence (i.e., they are regulating their PA behavior appropriately), it may positively influence their FOR.

There is also a significant amount of evidence indicating that being in an intimate relationship impacts mental and physical health. Especially relevant to the current study is the evidence for a link between the health behaviors of couples. These findings, in combination with the negative influence that FOR can have within a relationship, highlight the importance of better understanding the influence that each partner has on the other’s well-being. Therefore, a secondary goal of the study was to evaluate whether patient’s and spouse’s FOR and PA impacts their partner’s levels of FOR and PA.

**Study Aim 1: Establish links between fear of recurrence and physical activity.**

The first broad aim of this study was to establish links between FOR and PA. Based upon findings from previous studies examining the link between FOR and health behaviors, it was hypothesized that there would be a between-person concurrent relationship between these variables, such that those with higher overall levels of FOR would tend to be less physically active (Goodwin, 2003; Van Liew, Christensen, Howren, Karnell, & Funk, 2013). Additionally, it was hypothesized that there would be within-person links between concurrent FOR and PA, such that on a day during which an individual reported greater FOR than is typical, she/he would also engage in less PA. In addition to the amount of time an individual spends being physically
active, the intensity of the PA was included in analyses to determine whether the intensity of the activity plays an independent role on the relationship with levels of FOR.

The temporal nature of this relationship was also examined to determine whether FOR served as a leading indicator of PA, whether PA was a leading indicator of FOR, or both. Based on the findings related to mood and PA (e.g., Carols, Coit, Young, & Berger, 2007; DaSilva et al., 2012), it was hypothesized that FOR and PA would show a bidirectional relationship.

**Study Aim 2: Evaluate the influence of each patient and spouse’s FOR and PA on their partner’s FOR and PA.**

The second broad aim of this study was to evaluate relationship between fear of recurrence and engagement in PA within a dyadic context. Based on the interdependence theory, wherein close relationships are ones in which an individual’s thoughts, feelings, and behaviors influence their partner’s thoughts, feelings, and behaviors (Kelley et al., 1983; Rusbult & Van Lange, 2003), it was anticipated that there would be some relationship between increases in one partner’s FOR and the other partner’s PA. Support for this exploratory analysis came from an experience-sampling study by Dunton, Atienza, Castro, and King (2009) finding that a positive social interaction was concurrently associated with increased moderate-to-vigorous PA. The opposite relationship was hypothesized in the case of FOR such that days when both patient and spouse were experiencing more FOR, there would be an
additional effect of lowered PA levels for both. This relationship was tested using a patient-partner interaction term.
Chapter 2

METHOD

Overview

The current study used an intensive longitudinal design. Intensive longitudinal designs are ideal for examining everyday psychological processes as well as their temporal development over a specified period of time (Bolger & Laurenceau, 2013). For example, looking at between-person (cross-sectional) associations of PA and FOR would allow one to determine whether individuals who report being more physically active tend also to experience less FOR in general. However, intraindividual (longitudinal) analyses can answer questions such as whether or not an individual experiences less FOR on days in which they engage in more PA. Further, intraindividual analyses permit the evaluation of the impact of the timing, intensity, and/or frequency of PA on FOR. Moreover, using an intensive longitudinal design allows for the investigation of the temporal development of the relationship between variables like PA and FOR (i.e., whether changes in PA result in changes in FOR, vice versa, or both).

Participants

The study sample consisted of 71 post-surgery women and their partners. The patients had a primary diagnosis of stage 0, 1, 2, or 3a (i.e., early stage) breast cancer.
Additionally, the patient must have had breast cancer surgery within the last six months and had not been previously diagnosed with any type of cancer. The majority of patients did not engage in chemotherapy as an adjuvant treatment (66.7%), but did receive radiation (70.8%). A table summarizing the surgical procedures of the patients can be found in Table 1. The patient and partner were to be married or were in a long-term committed relationship and cohabitating. The study sample comes from a larger NCI-funded R21 project focused on better understanding the short term and longer term temporal course of FOR in both breast cancer patients and spouses. Participants were recruited based on a positive biopsy list of patients treated at the Helen F. Graham Cancer Center, which is a community cancer center that is part of the Christiana Care Health System in Newark, DE. Data for this specific study were drawn from the first 21-day diary burst, which was completed as soon as possible after their adjuvant treatment was completed (see Figure 2).
Table 1

Summary of surgery types for patients.

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Bilateral</th>
<th>Left</th>
<th>Right</th>
<th>Other</th>
<th>Totals (across)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modified radical mastectomy</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Total / simple mastectomy</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td></td>
<td>12</td>
</tr>
<tr>
<td>Prophylactic total / simple mastectomy</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Skin sparing mastectomy</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Lumpectomy / wide excision / segmental mastectomy / segmental resection</td>
<td>21</td>
<td>15</td>
<td></td>
<td></td>
<td>36</td>
</tr>
<tr>
<td>Excisional biopsy with needle localization</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Excisional biopsy</td>
<td>1</td>
<td>8</td>
<td></td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>Biopsy</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>L excisional biopsy X2 &amp; L partial mast X2</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>L lumpectomy &amp; R excisional biopsy</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>L simple mast &amp; R prophylactic simple mast</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>R skin-sparing mastectomy with chest wall reconstruction</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>L breast wide excision, wide excision secondary margins</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Wide excision with needle localization</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Totals (down)</strong></td>
<td><strong>8</strong></td>
<td><strong>29</strong></td>
<td><strong>28</strong></td>
<td><strong>6</strong></td>
<td><strong>71</strong></td>
</tr>
</tbody>
</table>
Figure 2

*Timeline of R21 study of fear of recurrence in breast cancer patients and their spouses.*

Seventy-two couples completed at least one of the 21 diary days, a criterion for study inclusion. The average number of completed diaries was 15. See Figure 3 for a detailed outline of study recruitment and participation. All participants who completed at least one diary day were included in analyses in order to increase generalizability to the population of patients we sampled from. Patients and spouses were mostly Caucasian (87.5% and 84.7%, respectively), non-Hispanic (98.5%), with mean ages of 57 and 59.3, respectively, and having a household income greater than $80,000.
Most couples were married (93.1%) and had been together for more than 30 years (52.8%).
Figure 3

Study recruitment throughout full timeline of R21 project.
Procedure

Data for this study were collected as part of a larger longitudinal study spanning up to one year. Objective PA data were collected using accelerometers that both patients and partners wore for 24 hours per day throughout the 21-day diary recording period. Accelerometers record not only the number of steps that a person takes, but also the intensity of their movement. These devices time and date stamp this information, which allows for the examination of objective PA patterns throughout the day as well as across days (Bassett, 2012). In addition to wearing the accelerometers, both patients and partners completed daily diaries in which they reported on their experience of FOR at the end of each of 21 consecutive days.

Participants were scheduled to have a home visit prior to the start of the daily diary recording period. At this visit, researchers collected height, weight, and waist circumference measurements, along with fitting each patient and partner with Actigraph™ brand wGT3X-BT accelerometers. Participants then completed daily, electronic diaries that contained multiple items pertaining to FOR each evening (approximately an hour prior to bedtime) for 21 consecutive days. Therefore, both patients and partners wore the accelerometers for the entire daily diary recording period.

All daily survey items were administered via a secure, online survey website (www.qualtrics.com) so that all participants could complete them from their home computers. If participants did not have a computer or access to the internet, arrangements were made at the time of the home visit to provide the couples with
temporary access to a laptop and a device that would provide wireless internet access (e.g., MiFi).

**Daily Measures**

**Fear of Recurrence.** FOR was assessed each evening for both patients and partners using an abbreviated version of the Fear of Cancer Recurrence Inventory (FCRI; Simard & Savard, 2009). The full FCRI is a 42-item comprehensive self-report measure of FOR. The full measure is comprised of seven subscales: triggers, severity, psychological distress, coping strategies, functional impairments, insight, and reassurance. To our knowledge there has been no previously published diary-based measure of FOR. Therefore, items were selected from the psychological distress and severity subscales as these were deemed most directly indicative of the construct of FOR. Items included in the daily diaries were combined to aid in reducing the burden on the participants, resulting in six FOR questions. For example, one item in the diary states “I was worried, afraid, or anxious about the possibility of cancer recurrence.” Table 2 contains the verbatim lead-in text and list of the FOR items included in the diary. Patients and spouses both indicated on a 5-point Likert scale ranging from “I didn't think about it at all” to “several hours” how much time they spent thinking about the possibility of cancer recurrence *today* for item 1. Patients and spouses both indicated on a 5-point Likert scale ranging from “not at all” to “extremely” how much they experienced each item *today* for items 2-6. Spouses completed complementary items assessing their concerns/worries about cancer recurrence for their partner using
the same response scale. Responses to FOR items were summarized into a single summed score.

Table 2

FOR Items Adapted from the Fear of Cancer Recurrence Inventory (Simard & Savard, 2007).

The following questions ask about thoughts and feelings you may have had today about the possibility of cancer recurrence. By cancer recurrence, we mean the possibility that breast cancer could return or progress in the same place or in another part of the body, OR having a different, new cancer.

1. How much time today did you spend thinking about the possibility of cancer recurrence?
2. I was worried, afraid, or anxious about the possibility of cancer recurrence.
3. I was sad, discouraged, or disappointed about the possibility of cancer recurrence.
4. I was frustrated, angry, or outraged about the possibility of cancer recurrence.
5. I felt helpless or resigned about the possibility of cancer recurrence.
6. I felt that I worried excessively about the possibility of cancer recurrence.

Note. Responses were provided on a 0-4 scale, with the anchor statements “I didn't think about it at all” and “Several hours” for question 1, and “Not at all” and “Extremely” for questions 2-6.

Within-person reliability was estimated for the total FOR composite scores using procedures described by Cranford et al. (2006) and Bolger and Laurenceau (2013) for variance component analysis. The resulting reliability index for change (Rc)
focuses on the systematic variance in participants’ FOR scores over the 21 diary days. The $R_c$ reliability estimates for within-person patient and spouse FOR were 0.89 and 0.88, respectively, indicating acceptable within-person reliability. The reliability estimates for patient and spouse average FOR were 0.99 and 0.95, respectively, also indicating acceptable between-person reliability.

**Physical activity and sedentary behavior.** Physical activity data were collected using wrist-mounted Actigraph, Inc. (www.actigraphcorp.com) tri-axial wGT3X-BT accelerometers that both patients and partners wore throughout the 21-day diary recording period to produce an objective measure of daily PA. This model of accelerometer provides raw acceleration data expressed in gravity (g) units from three orthogonal axes. The raw data allow increased control over data processing (Hildebrand et al., 2014). These devices also time and date stamp this information, which allows for the examination of objective PA patterns throughout the day and across days (Bassett, 2012). The sampling frequency of the wGT3X-BT ranges from 30 to 100 Hz; a 30-Hz sampling frequency was used in this study, which is the default sampling frequency used with ActiLife software when initializing the devices.

These devices were worn on each of the participants’ non-dominant wrist, and were secured using either a non-removable plastic band (similar to a hospital bracelet) or removable band (provided only if participants were expecting to use air travel, have medical procedures, or are limited due to work). There is increasing evidence for the validity of the wrist worn devices versus the customary hip worn devices for the measurement of PA (Bassett, 2012; Ozemek, Kirschner, Wilkerson, Byun, &
Kaminsky, 2014). Furthermore, securing the device to the wrist likely increases compliance as well as allows for the measurement of other variables that could impact PA, such as sleep. Devices were to be worn 24 hours a day, unless for the reasons listed above. The devices were water resistant up to one meter for 30 minutes and could be worn while showering or swimming. ActiLife software was used to configure the devices for data collection, as well as to download the data collected.

As wrist-worn accelerometer data are a more recent phenomenon, less work has been conducted on validating algorithms for scoring raw data from the wrist compared to the hip. Methods to estimate aspects of physical activity and activity from wrist worn accelerometers are developed in Hildebrand, van Hees, Hansen, and Ekelund (2014) and Staudenmayer, He, Hickey, Sasaki, and Freedson (2015). The present study utilized the scoring methods detailed in the Staudenmayer et al. (2015) paper. Briefly, statistical summaries of the accelerometer signals were computed, which were then used as covariates in models to estimate aspects of PA and sedentary behavior. Multiple linear regression was used to estimate metabolic equivalent of task (i.e., METs), and decision tree models were used to classify activity intensity and whether the individual was sedentary or not. Machine learning models were also considered. MET is a physiological measure expressing the energy cost of physical activities and can be thought of as an index of the intensity of the activity (Ainsworth et al., 2000). By definition, resting is a 1 MET activity, and an activity with a MET of 3, such as walking at a rate of 3.0 mph, would require three times the energy that a person consumes at rest. The potential inputs to these models are the statistical
summaries of acceleration that were mentioned previously. Further details regarding this process are outlined in Staudenmayer et al. (2015).

The specific PA variables used in the analyses were 1) combined moderate-vigorous intensity physical activity (MVPA) and 2) total nonsedentary time. The PA intensity categories were determined based on the estimated MET unit for each signal measured by the accelerometer. MET values are often categorized into light (i.e., MET of < 3), moderate (i.e., MET of 3-6) and vigorous activities (i.e., MET of > 6). MVPA is a variable that combines the counts of moderate and vigorous activities. Nonsedentary time was measured based on activity intensities above the threshold of 1.5 MET, which is approximately the average energy cost of sitting quietly. Total time in nonsedentary activity was combined in hours per day for each individual. In addition to these PA variables, sedentary behavior was also included in analyses. Sedentary behavior is operationalized as activities that involve sitting or lying down and low energy expenditure (Owen, Healy, Matthews, & Dunstan, 2010). Totals for sedentary time were also provided in daily sums of hours. These variables were selected based due to the fact that PA guidelines are provided in terms of moderate-vigorous PA. Additionally, previous research in the field in has shown MVPA to be related to prolonged survival, diminished treatment side effects, and enhanced health-related quality of life in cancer populations (Kuiper et al., 2012; Lynch, Cerin, Owen, Hawkes, & Aitken, 2008; Meyerhardt et al., 2006; Meyerhardt et al., 2009). Recent work also has begun to highlight the importance of total PA throughout the day as a predictor of physical health and quality of life outcomes (Healy et al., 2008; Lynch et
Therefore, total nonsedentary time was included in analyses as an indicator of total PA across all intensity levels. Furthermore, sedentary behavior has emerged an important variable due to its distinct associations with poorer physical and psychosocial health in cancer survivors (Lynch, Dunstan, Vallance, & Owen, 2013). Because of this, analyses also included in the study utilized sedentary time as a predictor.

Reliability indexes were not computed for each of the PA variables included in the analyses. In order to compute reliability scores in the manner utilized with FOR, a scale would need to be made up of multiple items or components. Each of the three activity variables (i.e., MVPA, nonsedentary time, and sedentary time) are each composed of a single score per day reflecting the amount of time spent in each activity averaged across the day.

**Subjective Sleep Quality.** Sleep quality was assessed each morning for both patients and partners by asking patients “how refreshed or rested do you feel after last night's sleep?” Patients and spouses both indicated their responses on a 6-point Likert scale ranging from “exhausted” to “refreshed.” Sleep quality was entered into models as a control variable only, not as a focal predictor or outcome. It was entered at both the within and between-person level.

**Control Variables**

**Body Mass Index.** Patient and partner’s height and weight were measured using an electronically calibrated digital scale (Health-O-Meter® Professional 349KLX) and stadiometer (Seca® 213) to the nearest 0.1 pound and 0.1 inch,
respectively. These values were then used to calculate each patient and partner’s Body Mass Index (BMI).

**Radiation Treatment.** Whether or not a patient received radiation treatment was coded as 0=no and 1=yes.

**Chemotherapy Treatment.** Whether or not a patient received chemotherapy treatment was coded as 0=no and 1=yes.

**Stage of Cancer.** Each patient’s cancer stage was coded as 0 (stage 0), 1 (stage 1a and 1b), 2 (stage 2a and 2b), and 3 (stage 3a). Because there was only one patient who had stage 3a breast cancer, she was combined with the patients who had stage 2 breast cancer.

**Employment Status.** Each patient and spouse reported on an initial cross sectional measure whether they were not working, employed part time, or employed full time.

**Data Analytic Approach**

The 21-day diary design of this study corresponds to a multilevel data structure where there are repeated measures of daily variables nested within individuals who in turn are nested within couples (Kenny, Kashy, & Bolger, 1998; Laurenceau & Bolger, 2005; Raudenbush & Bryk, 2002). For the purpose of clarity, all patients will be referred to as “patient” and all spouses or partners will be referred to as “spouse” when reporting study findings. Multilevel modeling of these data allows the multiple sources of interdependency reflected in repeated measures data of distinguishable partners from couple to be modeled appropriately. Data pertaining to each of the study aims
were analyzed using dyadic multilevel modeling (Laurenceau & Bolger, 2012) implemented in Mplus version 7 (Muthén & Muthén, 1998-2012).

Additionally, these analyses directly accounted for the fact that the daily predictor variables are comprised of both within-person (i.e., intraindividual) and between-person (i.e., interindividual) variability. All analyses were conducted to estimate associations between fear of recurrence and PA at both the within-person and between-person levels. The within-person predictors were entered into the model person-mean centered, meaning that they were centered around each participant’s data by subtracting the participant’s mean from his or her daily value of each variable. Between-person predictors were entered grand mean centered (i.e., the mean across all individuals subtracted from each individual’s score).

To examine both aims, a dyadic longitudinal model was used with the couple as the unit of analysis allowing for the investigation of both partner effects and actor effects. Partner effects exist when one person’s behavior (such as being more physically active) predicts an outcome in their partner. Actor effects exist when an individual’s own behavior predicts their own outcome (Cook & Kenny, 2005). Actor effects are typically estimated in the presence of partner effects and vice-versa. Kashy and Kenny’s (1999) Actor-Partner Interdependence Model (APIM) provides the framework for investigating links between an individual’s PA levels and the association with both their own outcomes and their partner’s outcomes. This model was chosen to evaluate both aims of the study based on the knowledge that participants are a subset of the population of women with breast cancer, as patients
had to be coupled to be identified as eligible for the study. The couple was used as the sampling unit, and therefore should be used as the unit of analysis. It should be noted that results from this study would be only generalizable to breast cancer survivors in long-term, committed relationships, not all breast cancer survivors, as there may be important differences in partnered versus single breast cancer survivors. Evaluating the study aims without placing the model within the context of the APIM framework would not fully utilize the richness in these dyadic data.
Chapter 3

RESULTS

Preliminary Analyses

The final dataset consisted of 71 couples reporting twice daily for up to 21 days for a maximum total of 1491 observations. The mean number of completed diaries was 15. Frequency distributions of FOR and PA/sedentary behavior for both patients and spouses were examined to determine whether normal-shaped distributions were present for the variables. FOR for both patients and spouses demonstrated count-shaped distributions, and were therefore were modeled as a zero-inflated poisson distribution when included outcomes (Atkins, Baldwin, Zheng, Gallop, & Neighbors, 2013). The count portion of zero for patient’s and spouses FOR was .57 and 74, respectively, indicating that 57% of patients’ and 74% of spouses’ reported scores of FOR were zero. The PA and sedentary variables demonstrated normal distributions. Additionally, paired t-tests were conducted to examine whether patients’ and spouses’ scores on all major study variables differed significantly. There was a trend towards patients’ and spouses FOR scores differing significantly ($p = .08$), such that patients reporting slightly higher FOR scores on average than their spouses. Scores for MVPA, nonsedentary time, and sedentary time did not differ significantly ($ps = .32$, .81, and .43, respectively).
Means and standard deviations for study variables are presented in Table 3 and within- and between-person correlations of all study variables are presented in Table 4. Mean levels of PA and sedentary behavior were consistent with studies of the general population (Vanhelst et al., 2012) and of cancer populations (Lynch et al., 2010; Lynch, Dunstan, Vallance, & Owen, 2013; Vallance, Boyle, Courneya, & Lynch, 2014;), such that participants spent the majority of their waking hours (i.e., over 60%) engaged in sedentary activities. Intra-class correlations (ICCs) were computed for all outcome and predictor variables as all study variables were measured daily for all participants. The ICC is a measure of dependency within the data and refers to the degree of similarity between data reported on days from the same individual. Stated differently, it provides a measure of the proportion of the total variance for a variable that is due to between-person variability. The ICC for the patient and spouse FOR scores were .58 and .45, indicating that 58% of the variability in FOR scores for patients and 45% of the variability for spouses were due to between-person differences, or the degree to which individuals within the sample differed from each other on average daily FOR. Thus, for patients, 42% of the variability was due to within-person variability, or how much individuals differ from day-to-day on their reports of FOR, and for spouses 55% of the variability was due to within-person variability. The ICC’s of the PA/sedentary behaviors variables used in the analyses are provided in Table 3.
Table 3

Means, Standard Deviations, and Intraclass Correlations for Major Study Variables.

<table>
<thead>
<tr>
<th>Variable</th>
<th>M</th>
<th>Within-Person SD</th>
<th>Between-Person SD</th>
<th>ICC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Patient</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fear of Recurrence</td>
<td>2.23</td>
<td>2.54</td>
<td>2.30</td>
<td>0.45</td>
</tr>
<tr>
<td>MVPA</td>
<td>104.76</td>
<td>40.94</td>
<td>59.06</td>
<td>0.68</td>
</tr>
<tr>
<td>Non sedentary time</td>
<td>6.48</td>
<td>1.49</td>
<td>2.21</td>
<td>0.69</td>
</tr>
<tr>
<td>Sedentary time</td>
<td>10.31</td>
<td>2.21</td>
<td>2.63</td>
<td>0.59</td>
</tr>
<tr>
<td><strong>Spouse</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fear of Recurrence</td>
<td>1.56</td>
<td>2.08</td>
<td>2.46</td>
<td>0.58</td>
</tr>
<tr>
<td>MVPA</td>
<td>114.56</td>
<td>44.02</td>
<td>66.53</td>
<td>0.70</td>
</tr>
<tr>
<td>Non sedentary time</td>
<td>6.56</td>
<td>1.81</td>
<td>2.46</td>
<td>0.65</td>
</tr>
<tr>
<td>Sedentary time</td>
<td>10.63</td>
<td>2.70</td>
<td>3.17</td>
<td>0.58</td>
</tr>
</tbody>
</table>

*Note. N = 71. Unit for MVPA is minutes, non sedentary and sedentary time is hours. FOR was reported on a 0-4 likert scale for each of 6 items, with a possible total score range of 0-24.*

Table 4

Within-Person Correlations between all Study Variables for Patient and Spouse.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. pFOR</td>
<td>0.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. pMVPA</td>
<td>0.01</td>
<td>0.56**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. pNon sedentary</td>
<td>0.00</td>
<td>-0.33**</td>
<td>-0.57**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. pSedentary</td>
<td>0.23**</td>
<td>0.00</td>
<td>0.02</td>
<td>0.02</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. sFOR</td>
<td>0.16</td>
<td>0.21</td>
<td>0.19**</td>
<td>-0.12*</td>
<td>-0.02</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. sMVPA</td>
<td>-0.02</td>
<td>0.14*</td>
<td>0.27**</td>
<td>-0.17**</td>
<td>-0.05</td>
<td>0.76**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. sNon sedentary</td>
<td>0.04</td>
<td>-0.13*</td>
<td>-0.20**</td>
<td>0.33**</td>
<td>0.11</td>
<td>-0.54**</td>
<td>-0.72**</td>
<td></td>
</tr>
</tbody>
</table>

*Note. “p” represents patient variables and “s” represents spouse variables. FOR = Fear of Recurrence, MVPA = moderate-vigorous physical activity, Non sedentary = total time physical activity, and Sedentary = total time spent sedentary. Unit for MVPA is minutes, non sedentary and sedentary time is hours. FOR was reported on a 0-4 scale, with a possible total score range of 0-24. * p < .05. ** p < .01.*
Primary Analyses

Aim 1: Linkages between FOR and PA

We first investigated the effect of FOR predicting PA and sedentary time for both patients and spouses. Included in these initial analyses was a test to determine if there was a curvilinear relationship between FOR and PA such that moderate levels of FOR would be related to increases in PA, but that extremes at either end of the spectrum would be will be related to less PA. To test for curvilinearity, a quadratic term was entered in the model as a predictor. Specifically, FOR was squared and included as additional predictor, in addition to the linear FOR term. However, a curvilinear relationship did not exist within the data, as the quadratic FOR term was statistically non-significant. As such, the remainder of the analyses examined the linear relationship between FOR and PA was conducted without the use of a quadratic term.

Depicted in Appendix B, Figure 4, the first aim of this study focused on the “actor” paths in the model, labeled $a_p$ and $a_s$ (i.e., actor-patient and actor-spouse, respectively). This first set of models represented the concurrent relationship between FOR and PA. FOR was entered as the predictor variable first based on the framework provided by the Lee-Jones et al. (1997) model, where FOR is conceptualized to influence subsequent behavior. A test of the temporal nature of the relationship between FOR and PA, as well as partner effects, are discussed below. For all models
run, we estimated random intercept only models because we encountered convergence problems when attempting also to estimate all the key slope random effects, which can be due to specifying an overly complex random effects structure. To increase parsimony and efficiency of the final models (Kenny, Kashy, & Cook, 2006), we constrained parameter estimates for the same key effects across patients and spouses when estimates were similar in magnitude and direction. To do this, we conducted chi-square (or deviance) difference tests between the fit of the model with the parameters constrained to be equal and the fit of the unconstrained model. In models where a nonsignificant chi-square (or deviance) test of the fit of these nested models indicated that the constraints were consistent with the data, the constrained parameters were reported in the final models where applicable.

No statistically significant within-person effects were found for patients or their spouses when each individual’s concurrent FOR was used to predict their own MVPA, total nonsedentary time, and total sedentary time (See Appendix B, Figures 5, 7, and 9 for further information). Additionally, sleep quality was entered as a control variable for these analyses, as a potential factor that may influence daily levels of both FOR and PA. However, including sleep quality in each of the analyses did not lead to changes in the results.

Because key parameters of interest were similar in magnitude and direction at the between-person level and the chi-square test of fit of these nested models indicated that the constraints were consistent with the data (MVPA: $\chi^2 = 2.89, p = .09$;
nonsedentary: $\chi^2 = 0.40, p = .53$; and sedentary: $\chi^2 = 0.00, p = .99$), we reported estimates from the constrained between-person model. Effects were found such that patients and spouses who had higher average FOR across the 21 days also engaged in less average MVPA ($b = -4.88, p < .001, 95\% CI = -7.90, -1.86$; Appendix B, Figure 6) and increased in their average time spent sedentary ($b = 0.24, p = .02, 95\% CI = 0.04, 0.44$; Appendix B, Figure 10). No statistically significant effects were found for total PA (i.e., nonsedentary time) for patients and spouses (Appendix B, Figure 8). Average sleep quality, BMI, cancer stage, whether or not the patient received chemotherapy or radiation, and employment status were all entered as control variables for these analyses, as potential factors that may influence average levels of both FOR and PA. Although not detailed in the Results, including these control variables both separately and entered simultaneously in the same model did not lead to changes in the results.

A second set of models was run in which MPVA, nonsedentary time, and sedentary time were entered into separate models as predictor variables of same day FOR as the outcome (see Appendix B, Figure 11). This was done in order to begin to evaluate the direction of effects among FOR and PA/sedentary behavior. A trend toward significant within-person effects was found for the actor path for spouses when sedentary behavior was used to predict FOR, such that on days in which spouses engaged in more sedentary behavior, they also reported increased FOR on that same day ($a_s, b = 0.04, p = .08, 95\% CI = -0.004, 0.08$; Appendix B, Figure 16). No significant actor effects were found for patients, and no significant within-person actor
effects were found for patients and spouses for MPVA and total nonsedentary time (Appendix B, Figures 12 and 14).

Significant between person effects were found for patients and spouses such that those who engaged in more total PA (i.e., nonsedentary time) averaged across the 21 days also reported less average FOR ($b = -0.21, p = .001, 95\% CI = -0.32, -0.09; b = -0.13, p = .001, 95\% CI = -0.18, -0.09$, respectively; Appendix B, Figure 15). For patients, when converted into a rate ratio, this finding equates to a 1-hour increase in total PA being related to 19% decrease in FOR on average. For spouses, this finding equates to 1-hour increase in total PA being related to 12% decrease in FOR on average. When constrained to be equal ($\chi^2 = 0.25, p = .62$), there was a trend for patients and spouses who engaged in more MVPA to also report less average FOR ($b = -0.003, p = .08, 95\% CI = -0.01, 0.00$; Appendix B, Figure 13). When converted into a rate ratio, this finding equates to a 1-minute increase in MVPA being related to .3% decrease in FOR on average. A constrained model was used ($\chi^2 = 0.09, p = .76$) to demonstrate that patients and partners who engaged in more sedentary time across the 21 days also reported increased average FOR ($b = 0.18, p = .00, 95\% CI = 0.09, 0.26$; Appendix B, Figure 17). When converted into a rate ratio, this finding equates to a 1-hour increase in sedentary time being related to 19 % increase in FOR on average. No other effects were found at the between-person level when using PA/sedentary time to predict FOR.
In summary for the above concurrent models, patients and spouses who reported higher average FOR across the 21-day diary period, also engaged in less average MVPA and more sedentary behavior. Further, when using PA/sedentary behavior as a predictor of FOR, patients and spouses who engaged in more total PA across the 21 days also reported less average FOR. Additionally, patients and spouses who engaged in more sedentary behavior on average, also reported higher average FOR across the 21 days. As sedentary behavior had significant results when both used as a predictor and an outcome, there was evidence of a bidirectional relationship between FOR and sedentary time. There was a similar trend for MVPA to exhibit a bidirectional link with FOR, however results were only trending towards significance when MVPA was used as a predictor.

In order to test the temporal nature of these variables, a third set of models were run (see Appendix B, Figure 18) where FOR on one day for each patient and spouse (indicated by FORPt and FORSp) was used to predict their respective next day PA level (indicated by PAPt+1 and PAsSt+1). The current day’s PA (i.e., MPVA, nonsedentary, and sedentary time) was entered as a control variable (PAPt), as well as the linear passage of time (t). To test whether FOR and PA had bidirectional effects, a fourth set of models were run where the current day’s PA was entered as the predictor and next day’s FOR was entered as the outcome variable (see Appendix B, Figure 25).

Because key parameters of interest were not in a similar magnitude and direction, a non-constrained model was used. Within-person actor effects were found
such that on a day that a spouse reported more FOR than usual, there was a trend towards engaging in more MVPA the next day ($b = 1.03, p = .06, 95\% CI = -0.06, 2.11$; see Appendix B, Figure 19). Similarly, there was a significant within-person effect for spouses such that on days when they reported more FOR than usual, they also engaged in more total PA the next day ($b = 0.07, p = .001, 95\% CI = 0.03, 0.11$; see Appendix B, Figure 21).

When PA/sedentary behavior was used as predictor of next day FOR, significant within-person effects were found such that on a day on which a patient engaged in more MVPA than was typical for them, they reported increased FOR the next day ($b = 0.002, p = .02, 95\% CI = 0.00, 0.004$; Appendix B, Figure 26). When converted to a rate ratio, this effect indicates that a 1-minute increase in MVPA was related to a .2% increase in next day FOR. There was trend towards a similar significant effect for spouses ($b = 0.002, p = .07, 95\% CI = 0.00, 0.004$). Further, there was a significant effect such that on a day in which a patient engaged in more sedentary behavior than usual, they reported less FOR the next day ($b = -0.03, p = .02, 95\% CI = -0.06, -0.01$; Appendix B, Figure 30). When converted to a rate ratio, this effect indicates that a 1-hour increase in sedentary behavior was related to a 3% decrease in next day FOR.

Between-person effects for patients and spouses demonstrated a similar pattern to the concurrent models, which is to be expected based on the nature of the analyses.
Full between-person results for the lead models are provided in Appendix B, Figures 20, 22, 24, 27, 29, and 31.

In summary, within these concurrent models, patients and spouses who reported higher average FOR across the 21-day diary period, also engaged in less MVPA and more sedentary behavior. Further, when using PA/sedentary behavior as a predictor of FOR, a bidirectional effect was found for sedentary behavior, as patients and spouses who engaged in more sedentary behavior on average, also reported higher average FOR across the 21 days. Patients who engaged in more PA across the diary period reported less average FOR. Lead models provided interesting within person results such that for partners, increased FOR on one day predicted more activity next day. For patients, increased activity on one day predicted increased FOR next day.

**Aim 2: The influence of each patient and spouse’s FOR and PA on their partner’s FOR and PA**

The second aim of the study was to evaluate the influence of each dyad member’s predictor on the other partner’s outcome. In addition to the actor paths noted above, partner effects, labeled $p_s$ and $p_p$ (partner spouse and partner patient, respectively) were included to evaluate whether each partner’s level of FOR impacted the other partner’s PA above and beyond any actor effects that were found (see Appendix B, Figure 4). In addition, an interaction term, labeled $FOR_{int}$ was entered into the model to test whether the partner effect depended on the size of the actor effect or vice versa. Stated otherwise, this term allowed for the evaluation of whether
there were differential effects on PA based on whether both partners experienced high FOR levels, both experienced low FOR levels, or one experienced high and the other low levels of FOR. This interaction term was comprised of the product of the patient predictor by the spouse/partner predictor (Campbell & Kashy, 2002; Cook & Kenny, 2005).

No significant within or between person partner effects were found when concurrent FOR was used to predict MVPA, total nonsedentary time, or total sedentary time. Additionally, no significant results were found for the interaction term at both the within and between person level. When PA/sedentary behavior was used to predict same day FOR, there was a significant within-person effect for the partner path for spouses such that on a day in which a spouse engaged in more sedentary behavior, their partners (i.e., the patients) tended to report more same day FOR ($b = 0.03, p = .01, 95\% CI = 0.01, 0.04$; Appendix B, Figure 16). When converted to a rate ratio, this indicates that a 1-hour increase in spouse sedentary behavior was related to a 3% increase in same day FOR for the patient. See Appendix B, Figures 5-10 and 12-17 for more information on partner paths for these concurrent models.

When FOR was used to predict next day PA, there were significant within-person partner effects such that on days when a spouse reported more FOR than what was typical for them, their wife (i.e. the patient) engaged in increased next day MVPA and total PA ($b = 1.81, p = .01, 95\% CI = 0.56, 3.06$ and $b = 0.06, p = .02, 95\% CI = 0.05, 0.12$, respectively; Appendix B, Figures 19 and 21). There were no significant
partner effects for patients and also no significant between person interactions. See Appendix B, Figures 19-24 and 26-31 for more details.
Chapter 4

DISCUSSION

An extensive literature exists linking PA to physical health benefits for cancer survivors, most notably in terms of lowering an individual’s risk of actual cancer recurrence. Moreover, physical activity has also been linked to improvements in psychosocial outcomes in cancer survivors. We sought to expand the literature on PA and cancer by focusing on FOR, a cancer-specific psychosocial variable that represents a top concern for patients and their significant others. We also sought to expand on the literature by investigating the relationship between FOR and objectively measured PA on a day-to-day basis, within the context of an intimate relationship.

As there has previously been little work done to explore the relationship between FOR and health behaviors in general, and both FOR and general health behaviors independently have been found to be important factors in the lives of cancer survivors, the first broad aim of this study was to establish links between FOR and PA. Based on previous evidence that increased levels of FOR can have a negative impact on health behaviors (Van Liew et al., 2013), it was hypothesized that there would be a between-person concurrent relationship between these variables, such that patients and spouses with higher overall levels of FOR would also tend to be less physically active. This hypothesis was supported by the data. Relatedly, there also appeared to be partial evidence for the hypothesis that FOR and PA would have a
concurrent bidirectional relationship. Specifically, patients and spouses who reported higher average FOR across the 21-day diary period also engaged in less MVPA and more sedentary behavior. Further, when using PA/sedentary behavior as a predictor of FOR, patients and spouses who engaged in more sedentary behavior on average, also reported higher average FOR across the 21 days. Thus, we found that patients and spouses who engaged in more PA across the diary period reported less average FOR. This information provides further evidence of the negative effects that FOR has on health behaviors, specifically PA, and highlights the importance of FOR as a significant concern for cancer survivors and their intimate partners. Further, while PA has been linked to other psychosocial variables such as depression and quality of life, the concurrent, bidirectional nature of these variables expands the knowledge base to include FOR as a psychosocial variable linked with PA.

Factors that may have confounded the relationship between FOR and PA were identified and controlled for at the between-person level. Potential factors that may have impacted the relationship between these variables included sleep quality, which may impacted an individual’s overall energy levels and thus ability to engage in PA, or made one more susceptible to increased levels of FOR. BMI was also controlled for due to its negative relationship with PA. Type of treatment that the patient engaged in was also included, as engaging in radiation and chemotherapy may impact levels of FOR as well as an individual’s ability to engage in PA. Furthermore, employment status was included as patterns of PA are different for people who work versus those
who do not. However, controlling for these variables did not significantly impact the between-person associations discussed above.

Beyond establishing between-person associations between these variables, we sought to evaluate whether within-person variability in daily FOR was linked to that of daily PA. It was hypothesized that there would be within-person links between concurrent FOR and PA, such that a day on which an individual reported greater FOR than is typical, she/he would also engage in less PA. It was also hypothesized that this relationship would be bidirectional, such that a day on which an individual engaged in more PA that is typical, she/he would report less FOR. However, our analyses show that this pair of hypotheses regarding concurrent within-person associations was not supported.

After considering a concurrent relationship between FOR and PA, the next goal of this study was to investigate the temporal nature of these variables to further understand the dynamic between them. Specifically, it was predicted that FOR on one day would have a negative impact on PA the next day, at both the between- and within-person levels. At the between-person level, similar effects were found to the concurrent models presented above, as would be expected. However, interesting patterns of results were found for patients and partners at the within-person level. Days on which partners reported increased FOR compared to what was typical for them, they engaged in more PA the next day. Patients demonstrated a contrasting pattern such that increased activity on one day predicted increased FOR the next day, while increased sedentary behavior predicted less next day FOR.
A potential explanation for this varying pattern between patients and spouses may be due to their having differing coping strategies for managing their FOR. For patients, PA may be a triggering reaction that increases next day FOR, whereas sedentary behavior may be viewed as “restful.” There is the possibility that PA may increase patients’ attention to physical symptoms of various sorts, or could trigger thoughts somehow reminding them that they just finished treatment. Patients may also have the mindset that “rest is best” after such treatments, despite the evidence indicating that engaging in PA can decrease post-treatment symptoms and increase quality of life (Healy et al., 2008; Kuiper et al., 2012; Lynch, Cerin, Owen, Hawkes, & Aitken, 2008; Lynch et al., 2009; Meyerhardt et al., 2006; Meyerhardt et al., 2009). For spouses, experiencing an increase in FOR on one day may serve as a motivating, as opposed to interfering, factor toward engagement in active coping responses, such as PA. For spouses, engaging in more PA may serve as a way to cope with FOR that they have for their wives, as well as any fear of a cancer occurrence for themselves. It is important to note that study findings indicate that while at the within-person level a patient may react to an increase in activity on one day with increased FOR the next, overall, at the between-person level, patients who engaged in more PA on average, also reported less FOR on average. Therefore, while increases in PA on one day may lead to a temporary increase in FOR the next day, increased average daily PA is related to decreased average daily FOR.

The second broad aim of this study was to evaluate the influence of being in a close relationship on the relationship between FOR and engagement in PA to
determine if this is an important context to consider. Research indicates that partners in close relationships often tend to report similar levels of health behaviors (Li, Cardinal, & Acock, 2013). This previously established concordant relationship was supported by this study, as patients’ and spouses’ levels of PA and sedentary behavior were not significantly different from one another. Patients and spouses’ FOR and PA also showed small to moderate correlations, with the exception of MVPA which was not correlated significantly. This demonstrates a type of “synchrony” between the members of the dyad. Similarly, previous research has established that each dyad member’s level of FOR can impact outcomes in the other member (Hodges & Humphris, 2009; Kim et al., 2011), although this relationship has not been examined with PA and sedentary behavior. Moreover, it was anticipated that there would be some relationship between increases in one partner’s FOR and the other partner’s PA (or sedentary behavior), such that days when both patient and spouse were experiencing more FOR, there would be an additional effect of lowered PA (or higher sedentary behavior) levels for both.

However, we found limited evidence to support this hypothesis. The results that emerged as significant indicated spouses had an influence on patients, such that a day on which a spouse engaged in more sedentary behavior than was typical for him/her, the patient reported more same day FOR than was typical. Additionally, days on which a spouse reported more FOR than was typical for him/her, their wives engaged in increased next day MPVA and total PA. However, patients did not appear to have an influence on spouse outcomes across all of the models. Previous
intervention studies that have targeted health behaviors of couples have had mixed results. This issue, combined with the lack of significant findings from the current study, underscores the potentially complex relationship between FOR and health behaviors in the context of a romantic relationship. A potential explanation for the lack of results from this study may be that patients’ and partners’ are not openly sharing this concerns for FOR with each other. Additionally, PA may not be a communal coping activity that couples engage in, and may instead be a more individual activity.

Overall, a critical factor that may have impacted the results of these study findings is that there was limited range in daily FOR scores across both patients and spouses, with few individuals reporting on the higher end of the scale (i.e., reporting high FOR). The low levels of FOR across patients and spouses thus could have attenuated potential associations between FOR and PA within the couple system, or the within- and between-person levels in some cases. Importantly, because of the low FOR levels, we were also unable to adequately test whether there was a curvilinear relationship between daily FOR and daily PA, such that very little and very high FOR would be an inhibiting factor for engaging in PA, and moderate levels would be a motivating factor for engaging in PA. Similar to anxiety, experiencing FOR is not necessarily or always a negative outcome. FOR could potentially serve as a motivating factor if experienced at adequate enough levels to incite change without becoming burdensome to the individual. If a broader range of FOR scores had been present, it would have served to elucidate better the relationship between these variables. The
majority of the variation present in FOR was accounted for at the between-person level, which may have impacted the trend towards more significant results at the between-person level.

**Study Strengths and Implications**

This study has multiple noteworthy strengths. Primarily, to our knowledge this work is the only study to date that has investigated the dynamic between FOR and PA, the temporal nature of this dynamic, and how this plays out in the context of a romantic relationship. This study addressed a recent call to utilize new methodologies to capture the dynamic contributions of psychosocial experiences that vary over time within individuals and between populations (McDonald, O’Connell, & Suls, 2015).

The method of data collection and time period during which the data were collected also represents a study strength. The use of accelerometers to measure PA and sedentary behavior in an objective, non-intrusive way provides a rich dataset for investigating the temporal nature of these variables, without increased burden on the participant. Furthermore, published PA studies utilizing accelerometers typically capture data over a 7-day period, regardless of the population being investigated. Expanding on this research, the present study collected accelerometer data over 21 consecutive days, providing a richer data set. This longer time period may be particularly important for the population included, as cancer patients were studied just following adjuvant treatment. Had a shorter time period been examined, changes in PA following that crucial time period would not have been captured and interpretation of the results would have been limited.
While there were few significant within-person results in this study, the knowledge that patients and spouses revealed different relationships between FOR and PA is important for guiding future studies of these variables. This information may contribute to understanding how to best assist cancer survivors in their adjustment to their post-treatment lifestyle. Specifically, findings at the within-person level that increases in PA led to increased next day FOR, could be used as psychoeducational information to patients of what to anticipate following engagement in PA post-treatment, and could also reinforce the message that “rest is not best.” Future studies should investigate this relationship between PA and FOR to understand better that particular dynamic (and to unpack what it is about PA that might influence next day FOR). Furthermore, study findings on the differential relationship between FOR and PA for patients and spouses could influence efforts to determine how PA factors into the coping behaviors or patients and their partners post cancer treatment. More broadly, research is needed to better understand the potentially differing approach to the use of health behaviors as a method to cope with post cancer treatment. Such research could inform efforts to help partners and patients maximize their mutual supportive and health promotion behaviors.

**Limitations and Future Directions**

While this study provides multiple pieces of information regarding two important cancer-survivorship variables, study findings should be considered in light of several limitations. First, within the analytic models only random intercepts were examined, and not random slopes. Generally, it is important to allow for the possibility
that the relationship between FOR and PA varies person-to-person, as not every individual may show the same level of association between these variables. However, the variances reflecting the between-person differences in these effects were so small and close to zero that the models had trouble estimating the more maximal random effects approach. Therefore, only random intercepts were modeled.

Additionally, there are significant limitations due to the restricted range and low variability of the FOR scores. Currently there exists no clear consensus on how to measure FOR or what should constitute a clinical cutoff for scores. While the items included in the daily diaries for this study were drawn from the best available information, there is still much to learn about the shorter and longer term nature of FOR and its measurement. FOR may be a variable that does not lend itself well to being measured on a daily basis, which may be reflected in the lack of within-person findings noted in this study. For example, FOR might vary more on a week-to-week or month-to-month basis than a day-to-day one. It could also be that FOR will show more variation across patients and spouses with a longer time period post treatment, as this study only examined one month post-treatment. Patients may experience increased or decreased FOR with more information about their functioning in the months immediately following treatment. The broader aim of the larger parent project from which this data came from is to examine the temporal nature of FOR, which may provide further insight into this issue. Additionally, there is the potential that the items selected for this study do not capture the full construct of FOR. The population from which the study sample was recruited may have also impacted FOR scores. This
population was generally older and of higher socioeconomic status, and previous literature indicates that higher FOR scores are associated with individuals of a younger age and of lower SES (Simard et al., 2013). In addition to the impact of older age on FOR scores, research has also demonstrated a drop in PA over time for aging adult populations (Sallis, 2000).

Another potentially limiting factor in this study relates to the method by which the PA data were collected. While utilizing a wrist-worn (versus hip-worn) accelerometer may have helped to increase compliance across the diary days, and also allow for the measurement of sleep, validation studies of scoring methods for this type of data are still being conducted. We made use of the most current scoring techniques available; however, future studies may develop more accurate algorithms for scoring.

Despite these limitations, this study does present multiple exciting future research directions. While multiple between-person variables that may have impacted the relationship between FOR and PA were controlled for, potential within-person third variables were not explored. Future work may seek to examine potential moderators of the relationship between FOR and PA to better determine under what conditions the relationship found between FOR and PA is bigger or smaller. For example, examining the link between whether or not person worked on a particular day, how stressful their day was may be within-person variables that could moderate the effect between FOR and PA. Investigating these variables more thoroughly may help explain some of the unexpected relationships at the within-person level, such as patients experiencing less FOR following days in which they engage in more
sedentary behavior than is typical for them. However, it is important to note that within-person third variables would not change the between person findings that have been established. Day-to-day variability cannot account for between-person associations and vice versa, such that between-person variables cannot be third variables that confound the within-person associations. Between-person third variables could affect the strength of the association at the within-person level. However again, we did not allow for that relationship to be modeled, as only random intercepts were included in the model and these are factors that would modify the slope, which we specified as a fixed effect.

With regard to the measurement of PA and sedentary time, there are several directions that could be taken to examine further the relationship between these variables and FOR. For example, assessing the length of PA bouts may be an important future direction. Currently, the data presented in this study were provided in activity totals averaged across the day. Evaluation time spent in “bouts” of certain activity intensity levels could have been an alternative way to capture PA. For example, while the totals for MVPA in this study were in approximately 100 minutes per day, this does not actually give an indication of whether or not individuals were getting the recommended daily 30 minutes of moderate-vigorous activity. In order to meet this recommendation, individuals need to engage in bouts of moderate activity lasting at least 10 minutes in length, in order to achieve the necessary cardiovascular benefits. Further, the daily MVPA recommendation is intended to be in addition to regular daily activity.
Another potential direction may include assessing not only the intensity of activities performed by individuals, but also the type of activity they are engaging in, and individuals’ perceptions about the role of PA in overall health and well-being. It may be that many individuals still view PA as a means of losing/keeping off weight as compared to an important factor for disease prevention. New methods in the field of machine learning principles are being developed to translate accelerometer data into specific types of movement, such as walking, running, and cycling (Staudenmayer, He, Hickey, Sasaki, & Freedson 2015). These data would allow for the comparison of same-intensity activities to determine if the type of movement is important in predicting outcomes such as FOR. Additionally, investigating specific types of lower-impact PA, such as yoga, may have yield relationships with psychosocial variables such as FOR.

Due to the lack of evidence found for partner effects in the models, future research may wish to utilize “proximity detection” advances in accelerometers that have been added to the market in the last year. This advance allows accelerometers to detect and log the presence of other devices within range. This technology could serve to better examine the nature of couples’ engagement in PA, to better determine if this behavior is done socially versus individually.

As these data are drawn from a larger study investigating the temporal nature of FOR, an important future direction will involve evaluating the relationship between FOR and PA/sedentary behavior different points in the trajectory of survivorship. The larger parent study has obtained a second 21-day diary burst from both patients and
This second diary burst overlaps with the patients’ first follow-up mammogram typically scheduled 1 year from initial diagnosis, and may provide interesting differences in both FOR levels and PA. Additionally, the inclusion of objectively measured sleep data in addition to subjective sleep data may yield an interesting future direction of work. Currently, the fields assessing objective sleep and objective PA data exist somewhat independently, likely due the complex nature of scoring and interpreting each. However, there is the potential for important relationships to be examined between these variables.

In addition to assessing PA as an important health behavior in the breast cancer survivor population, assessing various risk factors serves as a potential future direction. Given the pervasiveness and clustering of negative health behaviors (Spring, King, Pagoto, Horn, & Fisher, 2015), health behaviors, such as tobacco and substance use and diet/weight maintenance, should be investigated in relation to both PA and FOR. Studies should additionally include the measurement of mental health for patients and their partners, as mood may also impacts associations among FOR, PA, and health behaviors post-cancer treatment.

It will be important to consider how to package the information provided in studies such as this one for clinical dissemination. For example, should the focus on clinical intervention efforts moving forward be on increasing moderate-vigorous activity or on reducing sedentary behavior? In addition, it is unclear whether a potential intervention’s focus should be on decreasing the compromising behaviors or on increasing the health-promoting activities, as too much sitting has been
demonstrated to be distinct from too little exercise. Adding specific recommendations to reduce sitting time in addition to increasing PA may be beneficial (Owen, Healy, Matthews, & Dunstan, 2010). Certainly, the results from this study provide more consistent results for the relationship between increased time spent sedentary and increased FOR, as opposed to the PA variables.

**Concluding Comments**

In conclusion, this study sought to investigate the relationship between two important variables as breast cancer patients enter the survivorship stage, FOR and PA. While extensive literature bases exist FOR and PA independently, little work has been done to identify any important connections between the two. This study sought to address this gap in the literature by examining the dynamic between FOR and PA, the temporal nature of this dynamic, and how this plays out in the context of a romantic relationship utilizing rigorous methodology, including a 21-day diary and objectively measured PA from patients and spouses.

This study provides further evidence of the negative association FOR has with health behaviors, specifically PA, and highlights the importance of FOR as a significant concern for cancer survivors and their intimate partners. Specifically, results of this study lend support to the call for further understanding the negative impact sedentary behavior has on health. Our results add to the growing literature base that sedentary behavior has negative effects not just for health, but also for also for psychosocial concerns. Encouraging reductions in sedentary behavior in conjunction with encouraging increases in PA will continue to be an important area of focus.
As cancer treatments continue to improve, the population of cancer survivors and their significant others left to cope with changes in their post-treatment lives continues to grow. Therefore, it is important to understand and address the unique needs of this population of couples coping with breast cancer and related FOR. We hope the findings from this study contribute to understanding how to best assist cancer survivors in their adjustment to post-treatment lifestyle and potentially improve their quality of life.
REFERENCES


and women diagnosed with early stage prostate and breast carcinomas. *Cancer, 88*(3), 674-684.


Staudenmayer, J., He, S., Hickey, A., Sasaki, J., & Freedson, P. (2015). Methods to estimate aspects of physical activity and sedentary behavior from high-


Appendix A

UNIVERSITY OF DELAWARE INSTITUTIONAL REVIEW BOARD APPROVAL

DATE: February 21, 2013

TO: Jean-Philippe Laurenceau
FROM: University of Delaware IRB

STUDY TITLE: [434778-1] Fear of Recurrence in Cancer Patients and Spouses

SUBMISSION TYPE: New Project

ACTION: APPROVED
APPROVAL DATE: February 21, 2013
EXPIRATION DATE: February 20, 2014
REVIEW TYPE: Administrative Review

Thank you for your submission of New Project materials for this research study. The University of Delaware IRB has APPROVED your submission. This approval is based on CCHS IRB review and approval. This submission has received Administrative Review based on the applicable federal regulation and the University of Delaware IAA with Christians Care.

Please remember that informed consent is a process beginning with a description of the study and insurance of participant understanding followed by a signed consent form. Informed consent must continue throughout the study via a dialogue between the researcher and research participant. Federal regulations require each participant receive a copy of the signed consent document.

Please note that any revision to previously approved materials must be approved by this office prior to initiation. Please use the appropriate revision forms for this procedure.

All SERIOUS and UNEXPECTED adverse events must be reported to this office. Please use the appropriate adverse event forms for this procedure. All sponsor reporting requirements should also be followed.

Please report all NON-COMPLIANCE issues or COMPLAINTS regarding this study to this office.

Please note that all research records must be retained for a minimum of three years.

Based on the risks, this project requires Continuing Review by this office on an annual basis. Please use the appropriate renewal forms for this procedure.

If you have any questions, please contact Jody-Lynn Berg at (302) 831-1119 or jberg@udel.edu. Please include your study title and reference number in all correspondence with this office.
Appendix B
DATA FIGURES

Figure 4

Actor-partner interdependence model for concurrent links with FOR predicting PA.

Note. FOR= fear of recurrence, P= patient, S= spouse, a= actor path, p= partner path, int= interaction term, PA= physical activity, t= time, and e= error.
**Figure 5**

*Actor-partner interdependence model for within-person concurrent links with FOR predicting MVPA with results.*

*Note.* ● Represents random intercepts. Interaction term removed from figure for simplification as $p > .10$. Estimates listed above are non-significant findings. Number of couple’s data included for this analysis was 71 (of a possible 71) and the number of observations were 1110 (of a possible 1491).
Figure 6

Actor-partner interdependence model for between-person concurrent links with FOR predicting MVPA with results.

Note. represent random intercepts. Interaction term removed from model for simplification as $p > .10$. \(^c\) represents effects constrained to be equal. * $p < .05$.

Number of couple’s data included for this analysis was 71 (of a possible 71) and the number of observations were 1110 (of a possible 1491).
Figure 7

Actor-partner interdependence model for within-person concurrent links with FOR predicting nonsedentary time with results.

Note. ● represents random intercepts. Interaction term removed from figure for simplification as p > .10. No significant findings indicated in model. Number of couple’s data included for this analysis was 71 and the number of observations were 1112 (of a possible 1491).
Figure 8

Actor-partner interdependence model for between-person concurrent links with FOR predicting nonsedentary time with results.

\[ \text{FOR}_{\text{pt}} \leftrightarrow \text{FOR}_{\text{sp}} \rightarrow \text{NONSED}_{\text{pt}} \rightarrow \text{NONSED}_{\text{sp}} \]

Note. \( \bigcirc \) represents random intercepts. Interaction term removed from model for simplification as \( p > .10 \). \(^c\) represents effects constrained to be equal. Number of couple’s data included for this analysis was 71 and the number of observations were 1112 (of a possible 1491).
Figure 9

Actor-partner interdependence model for within-person concurrent links with FOR predicting sedentary time with results.

Note. ○ represents random intercepts. Interaction term removed from figure for simplification as $p > .10$. No significant results indicated in model. Number of couple’s data included for this analysis was 71 and the number of observations were 1112 (of a possible 1491).
Figure 10

Actor-partner interdependence model for between-person concurrent links with FOR predicting sedentary time with results.

Note. ○ represents random intercepts. Interaction term removed from model for simplification as p > .10. e represents effects constrained to be equal. * p < .05. Number of couple’s data included for this analysis was 71 and the number of observations were 1112 (of a possible 1491).
Figure 11

*Actor-partner interdependence model for concurrent links with PA predicting FOR.*

*Note.* FOR = fear of recurrence, P = patient, S = spouse, a = actor path, p = partner path, int = interaction term, PA = physical activity, t = time, and e = error.
Figure 12

Actor-partner interdependence model for within-person concurrent links with MVPA predicting FOR with results.

Note. ● represents random intercepts. Interaction term removed from figure for simplification as p > .10. No significant findings indicated in model. Number of couple’s data included for this analysis was 68 (of a possible 71) and the number of observations were 1201 (of a possible 1491).
Figure 13

Actor-partner interdependence model for between-person concurrent links with MVPA predicting FOR with results.

Note. ◉ represents random intercepts. Interaction term removed from model for simplification as p > .10. ◊ represents effects constrained to be equal. † p < .10. Number of couple’s data included for this analysis was 68 (of a possible 71) and the number of observations were 1201 (of a possible 1491).
Figure 14

*Actor-partner interdependence model for within-person concurrent links with nonsedentary time predicting FOR with results.*

Note. ● represents random intercepts. Interaction term removed from figure for simplification as $p > .10$. No significant findings indicated in model. Number of couple’s data included for this analysis was 64 (of a possible 71) and the number of observations were 1220 (of a possible 1491).
Figure 15

Actor-partner interdependence model for between-person concurrent links with nonsedentary time predicting FOR with results.

Note. ■ represents random intercepts. Interaction term removed from model for simplification as p > .10. * p < .05. Number of couple’s data included for this analysis was 64 (of a possible 71) and the number of observations were 1220 (of a possible 1491).
Figure 16

*Actor-partner interdependence model for within-person concurrent links with sedentary time predicting FOR with results.*

Note. ● represents random intercepts. Interaction term removed from figure for simplification as p > .1. * p < .05 † p < .10. Number of couple’s data included for this analysis was 64 (of a possible 71) and the number of observations were 1220 (of a possible 1491).
Figure 17

Actor-partner interdependence model for between-person concurrent links with sedentary time predicting FOR with results.

Note. \( \circ \) represents random intercepts. Interaction term removed from model for simplification as \( p > .10 \). \( \circ \) represents effects constrained to be equal. * \( p < .05 \).
Number of couple’s data included for this analysis was 64 (of a possible 71) and the number of observations were 1220 (of a possible 1491).
Figure 18

Actor-partner interdependence model with FOR predicting next day PA.

Note. FOR= fear of recurrence, P= patient, S= spouse, a= actor path, p= partner path, int= interaction term, PA= physical activity, t= time, and e= error.
Figure 19

*Actor-partner interdependence model for within-person links with FOR predicting next day MVPA with results.*

*Note.* ○ represents random intercepts. Interaction term removed from figure for simplification as p > .10. * p < .05 † p < .10. Number of couple’s data included for this analysis was 63 (of a possible 71) and the number of observations were 919 (of a possible 1420).
Actor-partner interdependence model for between-person links with FOR predicting next day MVPA with results.

Note. $\bigcirc$ represents random intercepts. † $p<.10$. Number of couple’s data included for this analysis was 63 (of a possible 71) and the number of observations were 919 (of a possible 1420).
Figure 21

Actor-partner interdependence model for within-person links with FOR predicting next day nonsedentary time with results.

Note. ● represents random intercepts. Interaction term removed from figure for simplification as p > .10. * p < .05. Number of couple’s data included for this analysis was 64 (of a possible 71) and the number of observations were 934 (of a possible 1420).
Actor-partner interdependence model for between-person links with FOR predicting next day non-sedentary time with results.

Note. represents random intercepts. Interaction term removed from model for simplification as p > .10. * p < .05. c represents effects constrained to be equal. Number of couple’s data included for this analysis was 64 (of a possible 71) and the number of observations were 934 (of a possible 1420).
Figure 23

Actor-partner interdependence model for within-person links with FOR predicting next day sedentary time with results.

Note. • represents random intercepts. Interaction term removed from figure for simplification as $p > .10$. No significant findings indicated in model. Number of couple’s data included for this analysis was 64 (of a possible 71) and the number of observations were 934 (of a possible 1420).
Figure 24

Actor-partner interdependence model for between person links with FOR predicting next day sedentary time with results.

Note. represents random intercepts. Interaction term removed from model for simplification as p > .10. * p < .05. represents effects constrained to be equal.
Number of couple’s data included for this analysis was 64 (of a possible 71) and the number of observations were 934 (of a possible 1420).
Figure 25

*Actor-partner interdependence model with PA predicting next day FOR.*

Note. FOR= fear of recurrence, P= patient, S= spouse, a= actor path, p= partner path, int= interaction term, PA= physical activity, t= time, and e= error.
Figure 26

Actor-partner interdependence model for within-person links with MVPA predicting next day FOR with results.

Note. ● represents random intercepts. Interaction term removed from figure for simplification as $p > .10$. * $p < .05$ † $p < .10$. Number of couple’s data included for this analysis was 62 (of a possible 71) and the number of observations were 902 (of a possible 1420).
Figure 27

*Actor-partner interdependence model for between-person links with MVPA predicting next day FOR with results.*

Note. represents random intercepts. Interaction term removed from model for simplification as p > .10. c represents effects constrained to be equal. Number of couple’s data included for this analysis was 62 (of a possible 71) and the number of observations were 902 (of a possible 1420).
Figure 28

Actor-partner interdependence model for within-person links with nonsedentary time predicting next day FOR with results.

Note. ● represents random intercepts. Interaction term removed from figure for simplification as \( p > .10 \). No significant findings indicated in model. Number of couple’s data included for this analysis was 63 (of a possible 71) and the number of observations were 917 (of a possible 1420).
Figure 29

*Actor-partner interdependence model for between-person links with nonsedentary time predicting next day FOR with results.*

*Note.* ○ represents random intercepts. Interaction term removed from model for simplification as $p > .10$. $^c$ represents effects constrained to be equal. † $p < .10$. Number of couple’s data included for this analysis was 63 (of a possible 71) and the number of observations were 917 (of a possible 1420).
Figure 30

*Actor-partner interdependence model for within-person links with sedentary time predicting next day FOR with results.*

Note. ● represents random intercepts. Interaction term removed from figure for simplification as p > .10. * p < .05. Number of couple’s data included for this analysis was 63 (of a possible 71) and the number of observations were 917 (of a possible 1420).
Figure 31

*Actor-partner interdependence model for between-person links with sedentary time predicting next day FOR with results.*

Note. ○ represents random intercepts. Interaction term removed from model for simplification as p > .10. • represents effects constrained to be equal. * p < .05. Number of couple’s data included for this analysis was 63 (of a possible 71) and the number of observations were 917 (of a possible 1420).