

A Biopsychosocial Study of the Mammography Pain Experiences
of Breast Cancer Survivors

by

Cindy Dawn Scipio

Department of Psychology and Neuroscience
Duke University

Date: _____

Approved:

Francis J. Keefe, Ph.D., Supervisor

Mary Scott Soo, M.D.

Timothy J. Strauman, Ph.D.

Redford B. Williams, Ph.D.

Dissertation submitted in partial fulfillment of
the requirements for the degree of Doctorate
of Philosophy in the Department of
Psychology and Neuroscience in the Graduate School
of Duke University

2009

ABSTRACT

A Biopsychosocial Study of the Mammography Pain Experiences
of Breast Cancer Survivors

by

Cindy Dawn Scipio

Department of Psychology and Neuroscience
Duke University

Date: _____

Approved:

Francis J. Keefe, Ph.D., Supervisor

Mary Scott Soo, M.D.

Timothy J. Strauman, Ph.D.

Redford B. Williams, Ph.D.

An abstract of a dissertation submitted in partial
fulfillment of the requirements for the degree
of Doctorate of Philosophy in the Department of
Psychology and Neuroscience in the Graduate School
of Duke University

2009

Copyright by
Cindy Dawn Scipio
2009

Abstract

Based on a biopsychosocial model of mammography pain, the current study assessed if specific biological and psychosocial factors were associated with higher reported mammography pain in early stage breast cancer survivors. One hundred and twenty-seven women completed questionnaires assessing demographic information, cancer treatment history, ongoing breast pain, mammography-related anxiety, and social support immediately prior to receiving a mammogram. They then completed questionnaires assessing mammography pain and mammography-related pain catastrophizing immediately following the mammogram. Using path modeling and mediation analyses, relations among these variables were examined. Results revealed that mammography-related pain catastrophizing was related to higher mammography pain directly, while ongoing breast pain, lower social support quantity, and lower perceived quality of social support related to higher mammography pain indirectly through mammography-related pain catastrophizing. Moderated mediation analyses found that the mediation effects of mammography-related pain catastrophizing were significantly different at varying levels of perceived quality of social support, with more pronounced negative effects for those with higher quality support than those with lower quality support. The theoretical, clinical, and research implications of these findings are discussed.

Dedication

I dedicate this work to my parents, Joan Caesar-Scipio and Cecil Scipio, and to the Caesar and Scipio families. Your love and support throughout the years has meant the world to me.

Contents

Abstract	iv
List of Tables	ix
List of Figures	x
Acknowledgements	xi
1. Introduction	1
1.1 The Importance of the Mammography Pain Experience	1
1.2 Potential Influence of Biological Symptoms and Psychosocial Factors on the Mammography Pain Experience	2
1.2.1 Biological Symptoms: Focus on Ongoing Breast Pain	3
1.2.1.1 Surgery and Auxiliary Treatment-Related Ongoing Breast Pain.....	4
1.2.1.2 Prevalence of Ongoing Breast Pain	6
1.2.1.3 Empirical Support of Ongoing Breast Pain Affecting Acute Pain	7
1.2.1.4 Comment.....	14
1.2.2 Psychosocial Factors: Pain Catastrophizing, Anticipatory Anxiety, and Social Support	15
1.2.2.1 Rationale Why Breast Cancer Survivorship is a Psychosocial Challenge..	16
1.2.2.2 Rationale for Psychosocial Factors Affecting the Pain Experience	17
1.2.2.3 Cognitive Factors: Focus on Pain Catastrophizing	19
1.2.2.4 Affective Factors: Focus on Anticipatory Anxiety	29
1.2.2.5 Psychosocial Factors: Focus on Social Support.....	37
1.2.2.6 Comment on Psychosocial Factors	46

1.2.3 Biological and Psychosocial Factors in Mammography Pain: Toward a Biopsychosocial Model of Mammography Pain.....	52
1.2.3.1 Ongoing Breast Pain Hypotheses	53
1.2.3.2 Social Support Hypotheses.....	54
1.2.3.3 Mammography-Related Anxiety Hypothesis.....	54
1.2.3.3 Mammography-Related Pain Catastrophizing Hypothesis.....	54
2. Method	56
2.1 Method Overview	56
2.2 Sample.....	57
2.3 Procedure.....	58
2.4 Measures	58
2.4.1 Pre-Mammogram Measures	58
2.4.1.1 Demographic Information and Cancer Treatment History	59
2.4.1.2 Ongoing Breast Pain.....	59
2.4.1.3 Mammography-Related Anxiety.....	60
2.4.1.4 Social Support.....	60
2.4.2 Post-Mammogram Measures.....	62
2.4.2.1 Mammography Pain.....	62
2.4.2.2 Mammography-Related Pain Catastrophizing.....	62
2.5 Data Analyses and Sample Size Determination.....	63
2.5.1 Overview	63
2.5.2 Path Analysis	63

3. Results.....	67
3.1 Demographic Information and Cancer Treatment History	67
3.2 Preliminary Analyses.....	71
3.3 Testing the Fit of the Hypothesized Model	72
3.4 Post-Hoc Analyses.....	77
3.4.1 Ongoing Breast Pain	77
3.4.1 Quality Social Support.....	78
3.4.2.1 Emotional Support Satisfaction.....	79
3.4.2.2 Guidance Support Satisfaction.....	80
4. Discussion	82
4.1 Summary of Findings.....	83
4.2 Study Strengths.....	97
4.3 Study Limitations	98
References	101
Biography	115

List of Tables

Table 1: Sample Sizes Needed for Power = 0.80, $\alpha = 0.05$, $H_0 p = 0.05$, $df = 31$, and $H_{alt} p = 0.10-0.15$	67
Table 2: Demographic Characteristics.....	68
Table 3: Cancer Diagnosis and Treatment History Characteristics	70
Table 4: Cancer Diagnosis and Treatment History Characteristics	71
Table 5: Intercorrelations Among Ongoing Breast Pain, Mammography-Related Pain Catastrophizing, Mammography-Related Anxiety, Social Support, and Mammography Pain.....	73

List of Figures

Figure 1: Anticipatory Anxiety, Pain Catastrophizing, and Perceived Low Quality Social Support Stimulating Mammography-Related Pain	18
Figure 2: Anticipatory Anxiety, Pain Catastrophizing, and Perceived Low Quality Social Support Stimulating Mammography-Related Pain	19
Figure 3: Anticipatory Anxiety, Pain Catastrophizing, and Perceived Low Quality Social Support Stimulating Mammography-Related Pain	55
Figure 4: Study Design Overview.....	57
Figure 5: Trimmed Path Model Excluding Catastrophizing.....	76
Figure 6: Trimmed Path Model Excluding Anxiety	77
Figure 7: Quality Social Support Mediation.....	79
Figure 8: Emotional Support Satisfaction Mediation.....	81
Figure 9: Guidance Support Satisfaction Mediation	82

Acknowledgements

First and foremost, I would like to thank my mentor Francis J. Keefe for the amazing research opportunities he provided to me throughout graduate school. I thank him for his guidance and support as I continue to develop as a young clinician and researcher. I also thank my other committee members, Mary Scott Soo, Timothy J. Strauman, and Redford B. Williams for their encouragement and support as I have developed this study over recent years. I am extremely grateful to have had so many positive mentoring experiences.

I also thank the many of the members of the Pain Prevention and Treatment Lab, including Rebecca Shelby, Meredith Rumble, LisaCaitlin Perri, Lisa Campbell, Laura Porter, Kim Dixon, Daphne McKee, Loren Caldwell, Elizabeth Chapman, Karen Cooper-Wurzburger, Kristen Dennis, Anna Yaros, Joshua Harris, Paige Johnson, Sandy Waters, and Mary Susan Pope. The guidance I received from them and laughter we shared over the years kept me motivated throughout the journey of graduate school.

I would like to thank my friends and family, including Ann Aspnes, Amy Mariaskin, Lisa Aberdeen, Deborah JaPaul, Vanessa Scipio, Selma Scipio, Omar Davis, Daniel King, Byron Wilson, Greg King, and Stefan Greenlee, for their love every step of the way.

Finally, I would like to express my gratitude to the breast cancer survivors who were willing to share their survivorship experiences with me.

1. Introduction

1.1 The Importance of the Mammography Pain Experience

In 2008, approximately 182,000 women will be diagnosed with breast cancer and over 2 million women will receive treatment for breast cancer in the United States (American Cancer Society, 2008). The experience of living as a breast cancer survivor can be very demanding, with a survivor facing many physical and psychosocial challenges. The process of undergoing annual mammography is one such challenge, since healthy women frequently report pain during the procedure (Kashikar-Zuck, Keefe, Kornguth, Beaupre, Holzberg, & DeLong, 1997; Keemers-Gels, Groenendijk, van den Heuvel, Boetes, Peer, & Wobbles, 2000; Papas & Klassen, 2005; Sapir, Patlas, Strano, Hadas-Halpern, & Cherny, 2003), with the number reporting moderate-to-severe pain ranging from 30-60% (Keemers-Gels et al., 2000; Sapir et al., 2003). In addition to mammography pain being a common experience, healthy women who report higher levels of pain during mammography have also reported reduced intention to undergo future mammograms (Andrews, 2001; Elwood, McNoe, Smith, Bandaranayake, & Doyle, 1998; Papas & Klassen, 2005). Importantly, breast cancer survivors have been found to report significantly more mammography pain than healthy women, with breast cancer survivors averaging over 30% more mammography pain than healthy controls (Kornguth, Keefe, Wright, & DeLong, 2000). So taken together, these findings indicate

that pain during mammography is common in breast cancer survivors, and may be correlated with reduced intention to undergo future mammograms.

While the mammography pain experience may be an important aspect of breast cancer survivorship, little is known about what factors influence the amount of mammography pain survivors report. Some biological and psychosocial factors may be particularly important in explaining why some breast cancer survivors report high levels of mammography pain while other survivors do not. The following sections will review how biological (ongoing breast pain) and psychosocial (pain catastrophizing, anticipatory anxiety, social support) factors may influence the mammography pain experiences of breast cancer survivors.

1.2 Potential Influence of Biological Symptoms and Psychosocial Factors on the Mammography Pain Experience

The following section is divided into three parts. In the first section, the research on ongoing/persistent breast pain in breast cancer survivors is reviewed for its potential influence on mammography pain. In the second section, pain catastrophizing, anticipatory anxiety and social support factors that may be present at the time of a mammogram are discussed for their potential impact on mammography pain. In the final section, a biopsychosocial model of the mammography pain experiences of breast cancer survivors is presented.

1.2.1 Biological Symptoms: Focus on Ongoing Breast Pain

Breast cancer survivors who are undergoing mammography often come into the procedure with biological symptoms related to cancer and its treatment. These biological symptoms can be quite common, and may have a significant influence on the experience of mammography-related pain. During the active treatment period, breast cancer patients often experience symptoms of fatigue and sleep-disturbance (Beisecker, Cook, Ashworth, Hayes, Brecheisen, Helmig et al., 1997; Degner & Sloan, 1995; Fortner, Stepanski, Wang, Kasprovicz, & Durrence, 2002; Stone, Ream, Richardson, Thomas, Andrews, Campbell, et al., 2003). However, as women progress from active treatment to survivorship, the symptoms of fatigue and sleep disturbance mostly dissipate, while other symptoms may persist for years following initial cancer treatment. Ongoing breast pain is one such symptom that may be experienced throughout the entire course of cancer survivorship (Ganel, Engel, Sela, & Brooks, 1979; Hilkens, Pronk, Verweij, Vecht, van Putten, & van den Bent, 1997), and can potentially be the most important biological factor associated with mammography-related pain. The possible link between ongoing pain and mammography pain is important for breast cancer survivors because a significant number of these women experience ongoing pain as a result of cancer treatment. For breast cancer survivors, ongoing breast pain can be the result of surgery, radiotherapy, and/or chemotherapy, (Ganel, et al., 1979; Hilkens, et al., 1997; Loudon & Petrek, 2000; Tasmuth, Kataja, Blomqvist, von Smitten, & Kalso, 1997).

1.2.1.1 Surgery and Auxiliary Treatment-Related Ongoing Breast Pain

Surgical treatment for breast cancer can lead to ongoing pain in a number of ways. First, many survivors report pain, tightness, and discomfort at the site of incision during the post-operative period. In one investigation of the acute postoperative period, Tasmuth and colleagues (1997) conducted univariate and multivariate analyses to determine what factors predicted ongoing breast pain in 509 breast cancer survivors. The researchers found that the intensity of acute post-operative pain significantly predicted ongoing breast pain in univariate analyses, with higher levels of acute post-operative pain predicting ongoing breast pain (Tasmuth et al., 1997). Interestingly, the researchers found that this relationship between acute incision post-operative pain and ongoing breast pain remained significant in multivariate analyses, even after considering the effect of the type of breast surgery (i.e. mastectomy or lumpectomy), or if the survivors underwent radiotherapy.

Second, when breast cancer patients receive axillary dissection in order to assess and limit disease progression, the removal of lymph nodes often disrupts the lymphatic system, resulting in lymphedema (i.e. the accumulation of protein-rich fluid in soft tissues; Loudon & Petrek, 2000). Breast cancer survivors with lymphedema have reported many physical complaints, including breast swelling, tenderness, and aching (Armer & Fu, 2005; Loudon & Petrek, 2000; Pyszal, Malyszczak, Pyszal, Andrzejak & Szuba, 2006). Pyszal and colleagues studied the prevalence of lymphedema in 283 breast

cancer survivors, and found that 31% reported lymphedema. When compared to breast cancer survivors without lymphedema, those with lymphedema reported significantly more pain and worse physical functioning.

Third, breast cancer surgery can also cause neuropathic pain when, during surgery, there is damage caused to the intercostobrachial nerves (Ganel, et al., 1979; Taylor, 2004; Vecht, Van de Brand, & Wajer, 1989). Previous research has found that breast cancer survivors who had intercostobrachial nerve damage as a result of breast cancer surgery reported significantly more pain than survivors without nerve damage (Taylor, 2004).

Fourth, for a small percentage of breast cancer survivors who undergo mastectomy, they experience phantom breast pain (i.e. pain experienced as coming from the removed breast). In a prospective study of 204 women undergoing mastectomy, Dijkstra, Rietman, & Geertzen (2007) followed breast cancer patients from the time of mammography to 2 years post-surgery. The researcher found that during those 2 years 1-8% of their study sample reported experiencing phantom breast pain.

Fifth, radiation therapy and chemotherapy have also been shown to predict pain and other sensory symptoms in breast cancer survivors. As was the case with axillary dissection, radiotherapy to the axilla has also been associated with lymphedema (Loudon & Petrek, 2000; Mondrup, Olsen, Pfeiffer, & Rose, 1990). Additionally, chemotherapy has been linked to neuropathic pain and sensory deficits. Breast cancer

survivors treated with chemotherapy have been found to have a dose-dependent level of neuropathic symptoms, with those treated with the highest doses reporting significantly more pain and sensory abnormalities (Hilkens et al., 1997).

1.2.1.2 Prevalence of Ongoing Breast Pain

Ongoing breast pain has been estimated to effect between 20-57% of breast cancer survivors (Bishop & Warr, 2003; Given, Given, Azzouz, Kozachik, & Stommel, 2001; Gottrup, Andersen, Arendt-Neilsen, & Jensen, 2000; Millar, Purushotham, McLatchie, Geogre, & Murray, 2005; Northouse, Caffey, Deichelbohrer, Schmidt, Guziatek-Trojniak, West et al., 1999; Rietman, Dijkstra, Debreczen, & de Vries, 2004; Stevens, Dibble, & Miaskowski, 1995; Uzun, Aslan, Seliman, & Koç, 2004). With ongoing pain being so common in breast cancer populations, it is a reasonable hypothesis that some survivors are experiencing ongoing pain at the time of mammography. This ongoing pain experience may influence the mammography pain experience, and survivors with a history of ongoing breast pain may report significantly more mammography-related pain than survivors without an ongoing pain history. Ongoing breast pain has been hypothesized to affect the acute pain experience by increasing sensitivity to stimuli (Gottrup et al., 2000).

1.2.1.3 Empirical Support of Ongoing Breast Pain Affecting Acute Pain

To date, only one study has evaluated how ongoing breast pain may influence acute pain in a breast cancer survivor population. The only study to evaluate this relationship was conducted by Gottrup and colleagues (2000). In this investigation, the researchers recruited breast cancer survivors who a) received surgery for breast cancer, b) had painful and non-painful sensory disturbances in the surgical site, axilla, or ipsilateral medial arm, and c) had no chemotherapy history. The researchers then conducted two pre-test pain assessments with the participants. The first pain assessment involved the participants reporting their typical breast pain intensity using a pain VAS (a 10-cm line anchored with “no pain” and “pain as bad as it can be” on either end) and the McGill Pain Questionnaire (MPQ; Melzack, 1975). The researchers then assessed touch sensitivity by dragging cotton gauze across the surgically-treated breast area, axilla, ipsilateral medial arm, and the participant-identified most painful/unpleasant area. This same procedure was conducted for the non-surgically treated side of the upper body in order to have a control comparison. Gottrup et al. then conducted a number of experimental pain procedures including tactile pain threshold, pressure pain threshold, temporal summation to pinprick stimuli, thermal pain threshold, and temporal summation to heat stimuli on the surgically-treated and untreated sides of the upper body. Data analyses included comparing differences in sensory pain thresholds, evoked pain with repetitive stimuli, and blood flow for 1) the

surgically treated versus untreated sides of the upper body and 2) survivors with pain versus those without pain.

Data analyses revealed some key findings. First, when comparing the treated versus untreated sides of the upper body, breast cancer survivors with and without ongoing breast pain both showed increased tactile detection on the affected side. More specifically, the treated breast was significantly more touch sensitive than the untreated breast. Second, when comparing survivors with ongoing pain to those without pain, survivors with ongoing breast pain reported lower heat pain thresholds, and more pain with repetitive tactile stimulation in the painful area during repetitive tactile stimulation. These results indicate that breast cancer survivors with ongoing breast pain may experience hyperalgesia and increased sensitivity to stimuli.

There were many aspects of this investigation that were particularly strong. First, the results provide evidence that breast cancer survivors with ongoing pain might have a different mammography pain experience than breast cancer survivors with no pain history. Although the study was not conducted at the time of mammography, the study did find significant differences in acute pain between women with ongoing breast pain and women with no pain. In addition, this investigation had methodological strengths worth noting. First, the investigators used multiple appropriate controls (i.e. non-treated breast, pain-free survivors), and by doing so, were able to provide evidence that breast cancer survivors with ongoing breast pain may have a particularly painful

experience during acute pain exposure, and suggests that investigating their pain experiences during mammography is warranted. Second, the researchers used a number of well-validated pain measures, including the pain VAS and the MPQ.

One important limitation of the Gottrup et al. (2000) investigation is that it was not conducted at the time of mammography. Assessing ongoing breast pain and acute pain during mammography could have made the results more relevant and clinically significant for breast cancer survivors. More specifically, it is unclear how often breast cancer survivors experience the types of pain stimuli that were utilized in the experiment in their normal lives.

Even though the study by Gottrup et al. (2000) has been the only one to investigate the influence of ongoing pain on perception of acute pain in a breast cancer population, a number of studies in the pain literature provide further evidence of the relationship between persistent pain and the experimental pain experience. Experimental pain can be defined as how an individual perceives pain during a laboratory based pain-inducing experiment. Many researchers have hypothesized that how an individual perceives experimental pain may correlate with his/her perception of ongoing pain (Clauw, Williams, Lauerma, Dahlman, Aslami, Nachemson, et al. 1999; Harris, Gracely, McLean, Williams, Giesecke, Petzke, et al. 2006; Staud, Robinson, Vierck, Cannon, Mauderli, & Price, 2003). Additionally, researchers have developed experimental pain procedures that attempt to mimic the clinical pain experience

(Geisser, Gracely, Giesecke, Petzke, Williams, & Clauw, 2007). In many of these studies, the investigators used standardized methods to evaluate the experimental pain experience of ongoing pain populations. The methods used typically involved the patients being assessed for their ongoing pain experiences followed by them being systematically evaluated for acute pain during a variety of experimental pain procedures. To assess ongoing pain experiences, researchers often administered standardized pain intensity measures, conducted a semi-structured pain history interview, and/or performed a comprehensive physical examination of the painful sites. To assess patients' acute pain perception, investigators have used a number of sensory testing measures including applying pressure, inducing skin thermal changes, applying tactile stimuli, and injecting saline solutions. A number of well-validated questionnaires have also been used to assess the pain associated with these experimental procedures, and these questionnaires are often administered both before and after the experiment. Data analyses often involved 1) comparing the acute pain experiences of ongoing pain participants to the experiences of pain-free individuals or patients with other ongoing pain conditions, 2) comparing the acute pain reported for the chronic pain site to the acute pain reported for non-painful sites, and/or 3) assessing the association between ongoing pain severity and experimental pain intensity.

Of those experimental procedures, investigations involving the assessment of pressure pain may be particularly comparable to the mammography pain experience for

a few key reasons. First, experimental pressure pain studies involve applying mechanical pressure to specific areas of the body and, during a mammogram, mechanical pressure is applied to the breast. Second, during pressure pain experimental studies, pressure is repeatedly applied to the same area of the body, as is the case during a mammogram. Breast cancer survivors are often required to receive repeated pressure applied to the breast during mammography in order to obtain an adequate image of the breast tissue. Third, a person's experiences during experimental pressure stimulation have been found to correlate with their persistent pain experience more closely than other experimental pain stimuli (i.e. heat, cold pressor; Geisser, et al., 2007). So taken together, the results of experimental pressure pain investigations may shed light on how breast cancer survivors with ongoing breast pain experience mammography.

Within the experimental pressure pain literature, a number of researchers have found significant correlations between having an ongoing/persistent pain history and the experimental pressure pain experience (Geisser, et al., 2007; Laursen, Bajaj, Olesen, Delmar, & Arendt-Nielsen, 2005; Staud, Koo, Robinson, Price, 2007). Within these investigations, individuals with a persistent pain condition have reported significantly higher levels of pain at a given level of mechanical pressure than healthy controls report and individuals with persistent pain have reported significantly lower pressure pain thresholds (i.e. the point at which pressure stimulation becomes painful) than healthy controls (Laursen et al., 2005; Staud et al., 2007). In one such pressure pain investigation,

Staud and colleagues evaluated pain intensity and pain 'aftersensations' in 11 fibromyalgia patients and 12 healthy controls. To assess the pressure pain experience, the researchers applied increasing levels of mechanical pressure using varying numbers of pressure probes applied to the participants' forearms. Using a 0-10 pain visual analogue scale (VAS), the participants rated 1) pain during the experiment and 2) pain that continued 15 and 30 seconds after the mechanical pressure was removed (i.e. pain aftersensations). The researchers were interested in evaluating if the participants with ongoing pain (i.e. fibromyalgia) reported higher levels of pressure pain than the pain-free controls. Additionally, the researchers were interested in evaluating the correlation between clinical pain and experimental pressure pain aftersensations for the fibromyalgia patients.

Data analyses revealed a number of statistically significant findings. First, when a single mechanical pressure probe was used, fibromyalgia patients reported significantly higher pain than pain-free controls reported at similar pressure levels (p 's $<.05$). Second, this same pattern was apparent when multiple mechanical probes were used, with fibromyalgia patients reporting significantly more pressure pain than was reported by healthy controls at similar levels of applied pressure (p 's $<.05$). Third, regarding pain aftersensations, data analyses revealed that fibromyalgia patients reported significantly more pain than healthy controls 15 and 30 seconds after the pressure probes were removed (p 's $<.05$). Fourth, when Staud et al. (2007) conducted

correlational analyses for clinical pain and experimental pressure pain for the fibromyalgia patients, they found that patients who reported higher levels of fibromyalgia-related pain were more likely to report higher experimental pressure pain aftersensations than patients with lower levels of fibromyalgia-related pain at both 15 and 30 seconds (p 's <.001). Taken together, these results indicate that individuals with a persistent pain condition may experience higher pain levels during experimental pressure pain conditions than healthy controls, and the experimental pressure pain condition may relate to the clinical pain experience.

Another study of experimental pressure pain was conducted by Laursen, Bajaj, Olesen, Delmar, and Arendt-Nielsen (2005). Like the Staud et al. (2007) study, the researchers compared the experimental pressure pain experiences of 40 persistent pain patients (i.e. fibromyalgia, endometriosis, low back pain, arthritis) to the experiences of 41 healthy controls. The participants were assessed for their pressure pain threshold (i.e. the point at which pressure from a probe becomes painful) at 7 different body sites: first joint of forefinger, forefinger pulpa, medial of scapula, lower abdomen, lower back, upper arm, and lower extremity. Data analyses revealed that for every body site, persistent pain patients reported significantly lower pressure pain thresholds than healthy controls (all p 's <.05).

Taken together, the investigations by Staud et al. (2007) and Larsen et al. (2005) had some noteworthy strengths. First, both investigations provided evidence that

individuals with persistent pain may experience more pain during experimental pressure pain procedures than do pain-free individuals. This common finding could be important for breast cancer survivors undergoing mammography, in that those survivors with ongoing breast pain may experience more mammography pain than pain-free survivors. Second, the researchers used well-validated methods and measures to evaluate pressure pain. By using these standardized methods, the researchers allowed for their methods to be compared to other experimental pressure pain studies, and enabled other researchers to replicate the method. In addition, one aspect of the Staud and colleagues study that was particularly strong is that the researchers included correlational analyses that showed the association between persistent pain and the experimental pressure pain experience. This finding provides evidence that perception of pressure pain may correlate with reports of persistent clinical pain.

1.2.1.4 Comment

Ongoing breast pain is a common symptom of breast cancer treatment. Since many survivors may be experiencing ongoing breast pain at the time of mammography, it can be hypothesized that this ongoing breast pain may influence the mammography pain experience. The findings of the study by Gottrup et al. (2000) lead one to believe that ongoing breast pain could predict more mammography pain in breast cancer survivors, since those survivors with ongoing pain reported more acute pain than survivors with no pain history. Additionally, when looking at the experimental

pressure pain literature, some results also suggest that having a persistent pain history significantly increases the level of experimental pain experienced. These investigations of ongoing/persistent pain and the acute/experimental pain experience had some common methodological strengths. First, the researchers used well-validated pain measures, including the pain VAS and MPQ. The use of standardized and well-validated pain measures allow for appropriate comparisons to be made across patient populations. Second, these studies provide evidence that the ongoing and acute/experimental pain experiences can both feasibly be assessed during a limited amount of time. This second point is imperative to the study of pain during mammography, since women have limited time to complete measures immediately before and after their mammograms.

While the investigations reviewed were not conducted with breast cancer survivors at the time of mammography, they still provided promising evidence that assessing ongoing breast pain at the time of mammography is warranted. First, an investigator can assess the ongoing pain experience of survivors using a well-validated measure before a scheduled mammogram. Second, to assess the mammography-related pain experience, survivors could complete a well-validated pain measure immediately following the mammogram.

1.2.2 Psychosocial Factors: Pain Catastrophizing, Anticipatory Anxiety, and Social Support

In addition to biological symptoms, breast cancer survivors undergoing mammography may also be affected by psychosocial factors that could influence the pain experience. First, this section will present a rationale for how the process of mammography may create cognitive, affective and psychosocial challenges. Second, this section will present a model of how these factors, specifically, pain catastrophizing, anticipatory anxiety, and social support, may influence the acute pain experience of mammography. Third, this section will present a review of the literature relating pain catastrophizing, anticipatory anxiety, and social support to the acute pain experience. If investigations have evaluated these factors at the time of mammography, they will be reviewed. However, if no previous investigations have been conducted with breast cancer survivors at the time of mammography, studies that assessed these variables in acute, experimental, or chronic pain conditions will be reviewed. Finally, this section will present a comment that summarizes key findings and highlights important issues related to the proposed study.

1.2.2.1 Rationale Why Breast Cancer Survivorship is a Psychosocial Challenge

The annual mammography experience may present a number of affective, cognitive, and psychosocial challenges. First, the mammography experience is a reminder that a breast cancer recurrence is possible. As such, an impending mammogram may be associated with anticipatory anxiety for some breast cancer survivors. Second, as a survivor is undergoing mammography, her methods for coping

with mammography-related pain may be maladaptive (i.e. catastrophizing). Third, at the time of mammography, a breast cancer survivor may perceive she is not receiving adequate support from her social network, which may contribute to the mammography-related affective and cognitive challenges she is already experiencing. These affective, cognitive, and social challenges may all contribute to a breast cancer survivor reporting mammography-related pain.

1.2.2.2 Rationale for Psychosocial Factors Affecting the Pain Experience

Melzack and Wall (1965) posited an influential hypothesis on how affective, cognitive, and psychosocial factors could affect the pain experience. The authors posited that within the spinal column, a series of nerve cells located within the substantia gelatinosa function as a gate to either transmit or block nerve impulses and pain perception. Melzack and Wall (1965) called this system the “gate control system,” and hypothesized that a number of factors could influence the perception of pain. As part of their theory of pain perception, they posited that pain perception could be a ‘top-down’ process. More specifically, psychological and psychosocial variables can trigger brain activity, which leads to the opening of the gating mechanism, and allows for stimuli to reach the brain, where it is perceived as painful. These top-down factors that lead increased pain perception could be affective (i.e. anticipatory anxiety), cognitive (i.e. pain catastrophizing), and/or psychosocial (i.e. perceived low quality social support). On the other hand, the authors posited that pain perception could also be inhibited by

psychological factors, leading to the activation of nerve fibers that inhibit the opening of the gating mechanism, thereby blocking stimuli from reaching the brain. These factors could also be affective (i.e. feeling calm), cognitive (i.e. belief that one can control pain), and/or psychosocial (i.e. perceived high quality social support). Two models for how psychological and psychosocial variables influence the mammography pain experience are presented below:

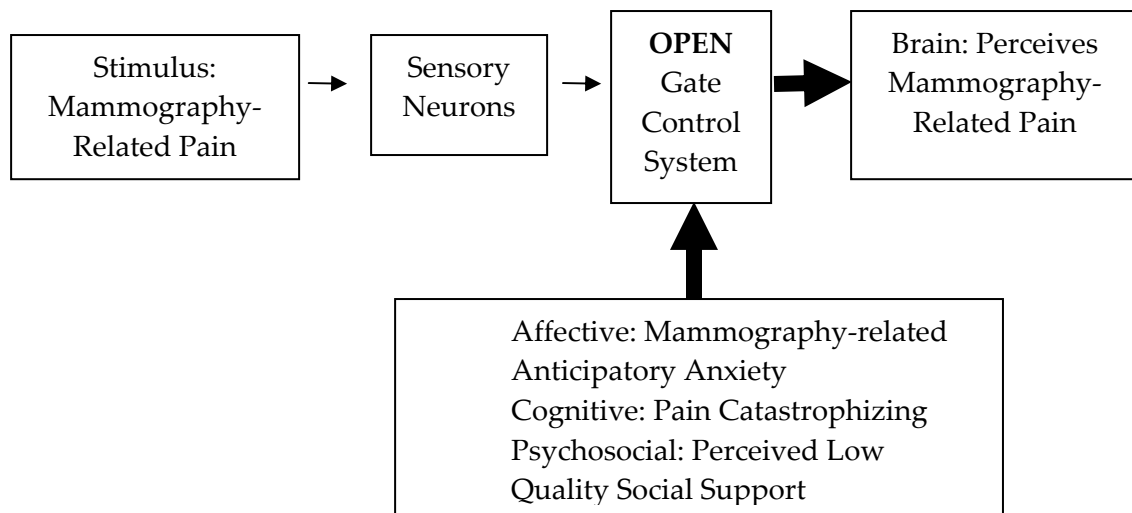


Figure 1: Anticipatory Anxiety, Pain Catastrophizing, and Perceived Low Quality Social Support Stimulating Mammography-Related Pain

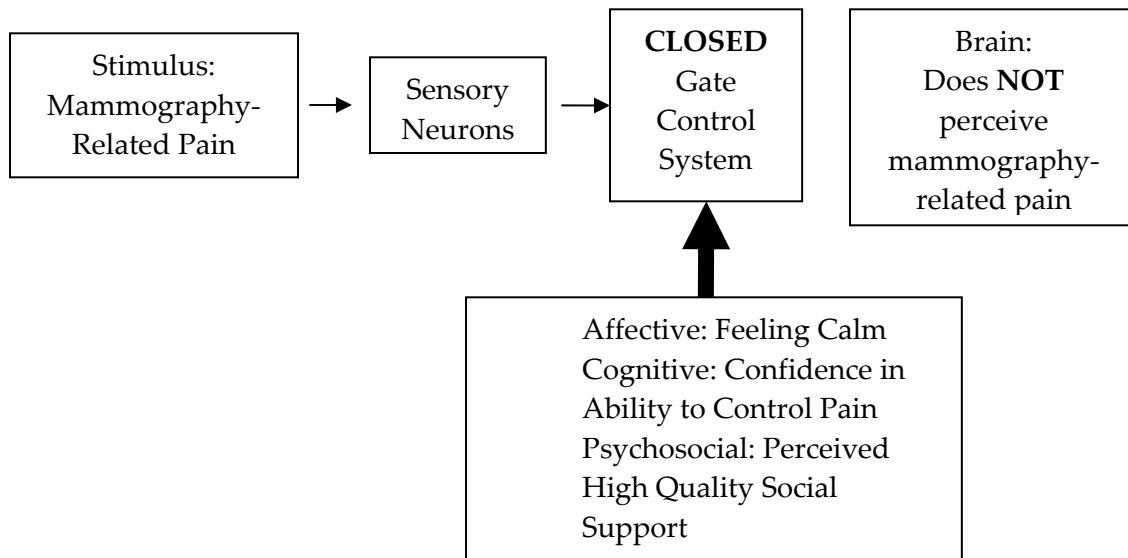


Figure 2: Anticipatory Anxiety, Pain Catastrophizing, and Perceived Low Quality Social Support Stimulating Mammography-Related Pain

1.2.2.3 Cognitive Factors: Focus on Pain Catastrophizing

One factor that may affect the pain experiences of breast cancer survivors undergoing mammography is pain coping. Pain coping can be defined as the skills that an individual uses to tolerate, reduce, or minimize pain (Rosenstiel & Keefe, 1983). Within pain coping, the usage of pain coping strategies has often been investigated for its role in the pain experience. Cognitive pain coping strategies consist of cognitive techniques that an individual develops to deal with pain. These strategies could either be adaptive or maladaptive, as determined by the individual's ability to reduce, tolerate or minimize pain when using them. One of the most studied maladaptive cognitive pain coping strategies is pain catastrophizing. Pain catastrophizing, defined as a cognitive process characterized by rumination, magnification, and helplessness about

the pain experience (Sullivan, Bishop, & Pivik, 1995), has specifically been the focus of a tremendous amount of research and is hypothesized to be strongly associated with higher reports of pain and emotional distress (for review, see Leeuw, Goossens, Linton, Crombez, Boersma, & Vlaeyen, 2007; Sullivan, Thorn, Haythornthwaite, Keefe, Martin, Bradley et al., 2001).

Pain catastrophizing could possibly be an important factor in the mammography pain experience of breast cancer survivors. In many investigations of the acute pain experience with a wide variety of participant populations, pain catastrophizing has been found to be significantly correlated with pain reports. More specifically, pain catastrophizing has been found to be significantly associated with higher pain reports in individuals experiencing postoperative pain (Granot & Ferber, 2005; Logan & Rose, 2005; Pavlin Sullivan, Freund, & Roesen, 2005) and experimental pain (Edwards, Smith, Stonerock, & Haythornthwaite, 2006; Thorn, Clements, Ward, Dixon, Kersh, Boothby, et al., 2004).

With the large number of previous investigations that suggest that higher levels of pain catastrophizing are correlated with higher pain reports, it could be hypothesized that it could also be an important factor in the mammography pain experience of breast cancer survivors. For example, if a survivor has pain catastrophizing thoughts during the procedure, these cognitions may be associated with more activation of pain pathways, and she may report high levels of pain throughout the mammogram.

Empirical Support for Pain Catastrophizing Affecting Mammography Pain

There have been a number of investigations that have evaluated pain coping strategies in the acute pain experience. Of these, 3 studies have specifically focused on the role of coping strategies in the pain experience at the time of mammography. Kashikar-Zuck, Keefe, Kornguth, Beaupre, Holzberg, and DeLong (1997) conducted a preliminary investigation of pain coping and mammography pain on 125 healthy women who were undergoing screening mammograms. Prior to the mammography procedure, the women were assessed for how they cope with day-to-day pain with the Coping Strategies Questionnaire (Rosenstiel & Keefe, 1983). The CSQ, a well-validated measure of pain coping, assessed 2 types of perceived effectiveness in pain coping strategies (i.e. effectiveness to decrease pain, effectiveness to control pain) and the frequency of usage of 7 pain coping strategies (i.e. catastrophizing, diverting attention, reinterpreting pain sensations, coping self-statements, ignoring pain sensations, praying or hoping, and increasing behavioral activity). The participants then underwent the mammography procedure, and immediately afterward, rated mammography-related pain on 4 pain measures: 1) the McGill Pain Questionnaire (Melzack, 1975), 2) a 0-100 mm pain VAS scale, 3) the Brief Pain Inventory (Cleeland, 1989), and 4) the Pain/Discomfort Rating Scale (Stomper, Kopans, Sadowsky, Sonnenfeld, Swann, Gelman, et al., 1988).

Data analyses revealed several important findings. First, the majority of the study participants experienced pain with mammography. More specifically, for the pain VAS, 88% of women reported experiencing pain, and over 30% reported at least a moderate level of pain (i.e. ≥ 40 mm) during the procedure. However, regarding the relationship between pain catastrophizing and mammography pain, there were no significant associations found.

The study by Kashikar-Zuck et al. (1997) had some strengths that are worth noting. First, the study presented good evidence that mammography is a painful event for the women who undergo the procedure. Second, the study methodology provides evidence that pain coping can feasibly be assessed at the time of mammography. Being able to assess pain coping during a mammogram allows for a better understanding of mammography as a challenge of survivorship. A better understanding of mammography pain coping allows for the eventual creation of interventions that reduce pain catastrophizing, with the goal of reducing mammography-related pain. Although there were strengths in this investigation, it did have some key limitations that are worth noting. One limitation was that the researchers asked the participants to complete the CSQ with regard to coping with day-to-day pain. Since breast cancer survivors are typically recommended to undergo mammography only 1 time per year, assessing how women cope with day-to-day pain may not be appropriate. A second limitation was that the participants were not assessed for how they cope with mammography-related

pain. These two limitations could have been addressed by including a modified measure that asked the women to report on pain coping strategy use during the mammogram. Based on the number and quality of the previous investigations that have found a significant relationship between pain catastrophizing and pain, the lack of significant findings in this investigation leads one to the conclusion that further research with different methodological techniques is warranted.

The only study that investigated pain coping at the time of mammography in breast cancer survivors was conducted by Kornguth, Keefe, Wright and Delong (2000). In a comparison of 99 breast cancer survivors and 125 healthy women, the investigators evaluated general pain coping strategy use. In order to assess how the participants cope with day-to-day pain, the participants completed the CSQ (Rosenstiel & Keefe, 1983) before undergoing mammography. After undergoing the mammography, the participants completed 4 well-validated pain measures: 1) the McGill Pain Questionnaire (Melzack, 1975), 2) a pain VAS, 3) the Brief Pain Inventory (Cleeland, 1989), and 4) the Pain/Discomfort Rating Scale (PDRS-Stomper et al., 1988).

Similar to Kashikar-Zuck and colleagues' (1997) study of mammography pain, data analyses revealed that women reported pain during the mammography procedure. Interestingly, the researchers found that breast cancer survivors experienced significantly more mammography-related pain than healthy women. When focusing on the breast that was treated for cancer, breast cancer survivors reported 32% more

mammography pain than healthy women. This difference between groups was significant on 3 out of the 4 pain measures (p 's < 0.0001). However, similar to the Kashikar-Zuck et al. investigation, no significant relationship found between pain catastrophizing and mammography-related pain.

The Kornguth and colleagues (2000) study was an important preliminary investigation of the mammography pain experiences of breast cancer survivors. The researchers found that mammography was painful, and significantly more painful for breast cancer survivors than healthy women. These findings highlight that breast cancer survivors may have a unique mammography pain experience, and further assessment as to what factors contribute to their experiences is warranted. However, the researchers were unable to find a significant relationship between pain catastrophizing and mammography pain. This lack of significant findings may have been due to the researchers assessing day-to-day pain coping. Assessing mammography-related pain coping may provide more information on the cognitive factors involved during the procedure than is gathered when focusing on day-to-day pain coping. To address this limitation, the researchers could have assessed pain coping following the mammogram, and could have instructed the participants to answer with regard to the procedure.

In a more recent investigation of healthy women undergoing mammography, the researchers Asghari and Nicholas (2004) addressed the limitations of the previous studies. The study sample consisted of 220 healthy women, and the participants were

asked about both their general pain coping and mammography-related pain coping. To assess day-to-day pain coping, the participants were asked to complete the CSQ (Rosenstiel & Keefe, 1983) before the scheduled mammogram, and were asked to answer with regard to day-to-day pains. To assess mammography-related pain coping, the women were asked to complete another CSQ after the procedure that focused on the strategies used to cope during the mammogram. After the procedure, the participants also completed 2 pain measures, the pain Visual Analogue Scale (VAS) and the Pain/Discomfort Rating Scale (PDRS-Stomper et al., 1988). The authors were interested in investigating if 1) day-to-day pain coping and mammography-specific pain coping were associated with mammography-related pain and 2) if day-to-day pain catastrophizing and mammography-specific pain catastrophizing significantly predicted mammography pain after considering other pain coping strategies (i.e. coping self-statements, praying & hoping, reinterpreting, increasing behavioral activity, ignoring pain sensation, diverting attention).

Similar to the results of the previous investigation, the data indicated that the majority of women reported pain with mammography. More specifically, 92% of the sample experienced pain during the procedure, and 43% rated this pain as moderate in intensity. Regarding the association between pain catastrophizing and mammography pain, the data revealed two statistically significant correlations. First, unlike the previously-reviewed investigations, day-to-day pain catastrophizing was significantly

correlated with mammography pain. More specifically, women who reported higher levels of day-to-day pain catastrophizing reported significantly more mammography pain than women who reported lower levels of day-to-day pain catastrophizing ($r = 0.27$, $p < 0.001$). Second, mammography-specific pain catastrophizing was significantly correlated with mammography pain. A higher level mammography-specific pain catastrophizing was related to higher mammography pain ($r = 0.43$, $p < 0.001$). Although mammography-specific pain catastrophizing was not significantly stronger correlated with pain than day-to-day pain catastrophizing (Fisher's $z = 1.399$, ns), the difference in the correlation values (r) is noteworthy. Third, when the authors conducted step-wise regression analyses, the results indicated that both mammography-specific pain catastrophizing and day-to-day pain catastrophizing predicted mammography pain even after considering other pain coping strategies. Interestingly, mammography-specific pain catastrophizing significantly predicted mammography pain on both pain measures (i.e. pain VAS, PDRS), while day-to-day pain catastrophizing predicted mammography pain for only 1 of 2 measures. Taken together, these findings provide some evidence that pain catastrophizing may be important to the mammography pain experience, and mammography-specific pain catastrophizing may be particularly predictive of mammography pain.

The study by Asghari & Nicholas (2004) was strong in a few ways. First, the researchers addressed an area that was lacking in previous research, the importance of

mammography-related pain catastrophizing. By doing so, they were able to detect a stronger correlation between mammography-specific pain catastrophizing and pain than between day-to-day pain catastrophizing and mammography pain. Second, the study provided evidence that pain catastrophizing may be more important to the mammography pain experience than other pain coping strategies. Therefore, instead of administering a complete pain coping battery (i.e. CSQ), future researchers could instead simply measure the usage of pain catastrophizing. Focusing on pain catastrophizing may help in identifying and intervening with those women who have maladaptive pain coping and experience mammograms as particularly painful. While the results of this investigation are promising, no breast cancer survivors were included as study participants. It may have been helpful to include breast cancer survivors to assess if the mammography pain experience is affected by having a cancer history.

Comment

Pain catastrophizing has been hypothesized to be an important factor in the pain experience (Leeuw, et al., 2007; Sullivan, et al., 2001). Investigations conducted with various populations have found higher levels of pain catastrophizing to be associated with higher reported pain (Granot & Ferber, 2005; Logan & Rose, 2005; Pavlin et al., 2005; Edwards et al., 2006; Thorn, et al., 2004). Based on these findings, it could be hypothesized that pain catastrophizing may be important to the mammography pain experiences of breast cancer survivors. In the three investigations of pain

catastrophizing and mammography that have been conducted, the investigators found mixed results. Asghari & Nicholas found that higher day-to-day pain catastrophizing and mammography-specific pain catastrophizing to be associated with higher mammography pain. However, neither Kashikar-Zuck et al. nor Kornguth et al. found this relationship to be significant. Additionally, Asghari & Nicholas were the only researchers to evaluate mammography-specific pain catastrophizing, but they found good evidence that mammography-specific pain catastrophizing may be important to the mammography pain experience. While the findings differed between studies, all three investigations had some key strengths. First, the researchers used good methodology and provided strong evidence that pain catastrophizing can be assessed at the time of mammography in a practical way. Second, all three studies used well-validated measures of pain coping and acute pain. This allowed for the results of the three investigations to be compared in a meaningful way. Third, the one investigation of breast cancer survivors' mammography pain experiences of breast cancer survivors found that survivors reported significantly more pain with the procedure than healthy women. This finding suggests that breast cancer survivors may have a unique pain experience at the time of mammography.

Although these studies provide preliminary evidence that pain catastrophizing may be important to the mammography pain experience, further investigation is warranted since only one of these investigations was conducted with breast cancer

survivors. Future studies should assess mammography-specific pain catastrophizing for a few key reasons. First, the Asghari & Nicholas (2004) study presented preliminary evidence that there may be a stronger relationship between mammography-specific pain catastrophizing and mammography pain than between day-to-day pain catastrophizing and mammography pain. Second, the assessment of pain coping may be more easily implemented at the time of mammography if researchers focus on the variables that are likely to be most relevant to mammography pain. Third, since survivors typically only undergo mammography once a year, assessing day-to-day pain coping may not accurately capture how they cope during an infrequent pain stimulus.

1.2.2.4 Affective Factors: Focus on Anticipatory Anxiety

In addition to pain catastrophizing, anticipatory anxiety may also be important to the mammography pain experience of breast cancer survivors. As stated earlier, Melzack & Wall (1965) posited that affective states may trigger brain activity, leading to the opening or closing of the gating mechanism in the neuraxis. More specifically, negative affect (i.e. anxiety) has been hypothesized to stimulate the opening of the gate, allowing for sensory stimuli to reach the brain.

The possible influence of affective state on the pain experience is important for breast cancer survivors because anxiety has been found to be a common experience of cancer survivorship. More specifically, investigators have assessed the rates at which breast cancer survivors report cancer-related anxiety and post-traumatic stress

symptoms. The rates of anxiety have typically been found to be more prevalent at the time of diagnosis, with one study by Jacobsen, Bovbjerg, and Redd (1993) finding that 91% of their breast cancer population reported anticipatory anxiety at the time of their first chemotherapy infusion. Importantly, breast cancer survivors have also been found to report anxiety while undergoing mammography. In one investigation comparing breast cancer survivors to healthy women, researchers found that breast cancer survivors experienced significantly more acute stress symptoms (i.e. hyperarousal, intrusion, anxiety) about undergoing a mammogram and receiving the results of mammography than women with no history of breast cancer (Gurevich, Devins, Wilson, McCready, Marmar, & Robin, 2004). Surprisingly, little research has been conducted to evaluate positive affect in breast cancer survivors.

With anxiety being so prevalent in breast cancer survivors, it can be hypothesized that anticipatory anxiety: a) may be present at the time of mammography, and b) may increase the amount of pain experienced during a mammogram. While the relationship between anticipatory anxiety and pain has not been evaluated during the mammography experience, researchers have explored the potential influence of anxiety and stress-related symptoms on the pain experience of breast cancer survivors.

Empirical Support for Anxiety Affecting the Pain Experience

Within the breast cancer survivor population, studies of the association between anxiety and pain have mainly focused on the cancer surgery period. In one such

investigation, Montgomery and Bovbjerg (2004) evaluated 63 breast cancer patients for their preoperative distress and postoperative physical symptoms. To evaluate preoperative negative affect, the participants were asked to rate surgery-related distress on a 0-100 visual analogue scale while they were waiting in the pre-operative waiting room. Other measures, including expectancies for pain, fatigue, and nausea were also assessed at that time. Postoperatively, the women rated surgery-related symptoms including pain intensity, pain unpleasantness, discomfort, nausea, and fatigue on 0-100 visual analogue scales. The researchers were testing 2 hypotheses regarding distress and pain: 1) preoperative distress and postoperative pain would be positively correlated, and 2) preoperative distress would predict postoperative pain independent of preoperative expectancy for pain.

Data analyses revealed a number of statistically significant correlations. Preoperative distress was significantly positively correlated with postoperative pain intensity ($r = 0.36, p = 0.004$), pain unpleasantness ($r = 0.24, p = 0.05$), and discomfort ($r = 0.33, p = 0.009$). Regarding the unique contribution of preoperative distress on pain outcomes, simultaneous regression analyses revealed that preoperative distress uniquely predicted discomfort at a statistically significant level even when preoperative pain expectancy was considered ($F(1,62), p = 0.05$). Taken together, these findings suggest that negative affect immediately prior to a medical procedure should be considered as an important factor in the postoperative pain experience.

The study conducted by Montgomery and Bovbjerg (2004) had a few key strengths that are worth noting. First the method of assessing survivors while they were waiting for their surgical procedures captured negative affect at a particularly meaningful period. Using this preoperative window allowed for the researchers to assess present-time distress, and greatly reduced the potential for recall error. Second, by conducting regression analyses, the researchers were able to determine the unique contribution of preoperative distress on pain and discomfort. The study did have one noteworthy limitation, however. The researchers did not use any standardized measure of anxiety, and assessed “distress” on a visual analogue scale. By not using standardized measures, it becomes more difficult to compare the study findings to those of anxiety and pain in other populations. So overall, the study provided some good evidence of a correlation between negative affect and pain, but still had room for improvement.

Katz, Poleshuck, Andrus, Hogan, Jung, Kulick et al. (2005) conducted an investigation of anxiety and postoperative pain that addressed the limitation of the previous study. In a sample of 109 women scheduled for breast cancer surgery, the researchers assessed how anxiety, cancer-related emotional distress, and depression were associated with acute and persisting pain postoperatively. To assess anxiety, the researchers used 2 well-validated measures: the state version of the State-Trait Anxiety Inventory (STAI; Spielberger, 1977), and the Hamilton Anxiety Rating Scale (HARS;

Hamilton, 1959, 1960). The researchers also assessed cancer-related emotional distress with 3 measures: the Functional Assessment of Cancer Treatment- Emotional scale (FACT-E; Brady, Cella, Mo, Bonomi, Tulsky, Lloyd et al., 1997; Cella, Tulsky, Gray, Sarafian, Linn, Bonomi et al., 1993), the Somatosensory Amplification Scale (Barsky, Wyshak, & Klerman, 1990), and the disease conviction scale of the Illness Behavior Questionnaire (Pilowsky & Spence, 1975, 1994). Unfortunately, the investigators did not report on the reliability or validity of the cancer-related emotional distress questionnaires. The researchers also used well-validated measures of depression (BDI-Beck, Ward, Mendelson, Mock, & Erbaugh, 1961; Hamilton Depression Rating Scale-HDRS; Hamilton, 1959, 1960). All of the measures of anxiety, cancer-related emotional distress, and depression were assessed the week before surgery. To assess acute and persisting post-operative pain, the researchers contacted the participants 2, 10, and 30 days after surgery and assessed pain on a 0-10 numerical rating scale. The researchers considered postoperative pain to be clinically meaningful if it was rated as ≥ 5 on the rating scale. The researchers conducted analyses to assess: 1) if survivors with meaningful levels of postoperative pain reported more anxiety and emotional distress than survivors without meaningful pain, and 2) if anxiety and cancer-related distress could predict the presence of meaningful pain levels independent of with demographic and surgery-related variables.

Analyses revealed a number of statistically significant findings. First, regarding acute postoperative pain, more than half of the survivors reported clinically meaningful pain levels. More specifically, 54% of the breast cancer patients reported their pain 2 days after surgery as ≥ 5 on the rating scale. This finding is important because it suggests that a number of breast cancer patients face a very painful recovery period, and could possibly benefit from intervention for reducing pain during this period. Second, regarding the association between anxiety and acute pain (i.e. 2 days postoperative), breast cancer patients who reported more anxiety symptoms were significantly more likely to report clinically meaningful acute pain than breast cancer patients with less anxiety symptoms ($p < 0.01$).

Regarding persisting pain, 14 women (12%) met criteria for experiencing clinically meaningful persisting pain (i.e. 10-30 days postoperative). This result suggests that a proportion of breast cancer survivors experience high levels of postoperative pain for an extended period of time, and may go on to suffer from treatment-related pain on a more chronic basis if untreated. Second, anxiety was again found to be associated with pain reports. More specifically, breast cancer patients who reported more anxiety were significantly more likely to report clinically meaningful persisting pain than breast cancer patients who reported less anxiety ($p < 0.01$).

The researchers also conducted predictive analyses to determine the degree to which anxiety could predict acute and persisting postoperative pain independent of

demographic, disease-related, and surgery-related variables. In these analyses, anxiety was found to be the only negative affect variable (i.e. anxiety, cancer-related emotional distress, depression) that predicted both acute and persisting acute pain independent of demographic, disease-related, and surgical variables. This means that researchers and clinicians could possibly consider pre-surgical anxiety levels as an important factor in the postoperative pain experience.

All together, the findings of the Katz study suggest that anxiety may be associated with higher postoperative pain, and pre-surgical anxiety levels may predict postoperative acute and persisting pain. This investigation by Katz et al. (2005) was strong in a number of ways. First, the methods used to evaluate acute and persisting pain were systematic and seemed to capture breast cancer survivors during meaningful periods post-surgery. This method of following women for 30 days allowed for survivors who were at risk for developing long-term pain to be identified, and possibly treated for pain. Second, the researchers used 2 very well-validated measures of anxiety to evaluate if different symptoms showed varying associations with pain. Finally, by using predictive analyses, the researchers were able to evaluate the independent contributions of different negative affect states on pain, and found that anxiety symptoms influenced postoperative pain above all other negative affective states that were measured. This final strength has the potential clinical implication that researchers

may be able to identify breast cancer survivors who are more likely to experience more postoperative pain based on their pre-surgery anxiety.

Comment

Two investigations have found higher preoperative anxiety and distress to be associated with higher postoperative pain reports in breast cancer patients. One study also found that preoperative anxiety predicted postoperative pain reports. These studies of the association between anxiety and pain in breast cancer survivors had a few methodological strengths worth noting. One strength is that the researchers for both studies focused on a discrete cancer-related event, breast cancer surgery. By concentrating on a cancer surgery, the researchers were able to assess anxiety, distress, and pain during an acute event that many breast cancer survivors face. Second, these studies also suggested that anxiety and pain can feasibly be assessed during the pre- and postoperative period. Assessing these factors immediately prior to and following surgery reduced the likelihood that the results were influenced by recall difficulties. Similar methods could be applied to investigating anxiety and mammography pain, by assessing anxiety immediately before the mammogram and mammography pain immediately afterwards. Third, the longitudinal design of the Katz et al. (2005) investigation enabled the researchers to evaluate the influence of anxiety on the persisting pain experience. Since a percentage of breast cancer survivors go on to suffer

persistent pain for years after treatment, it becomes very important to determine the factors that make some survivors more susceptible to persistent pain than others.

Taken together, these findings suggest that anxiety may be associated with the mammography pain experiences of breast cancer survivors. However, since no prior investigations have been conducted to evaluate this association, a preliminary study could assess mammography-related anticipatory anxiety immediately before the procedure, and mammography pain immediately after the procedure. Researchers have previously assessed breast cancer survivors for anticipatory anxiety at the time of mammography using the Stanford Acute Stress Reaction Questionnaire (SASRQ; Cardeña, Koopman, Classed, Waelde, & Spiegel, 2000), showing that such a measure could feasibly be implemented at the time of a routine annual appointment.

1.2.2.5 Psychosocial Factors: Focus on Social Support

In addition to pain catastrophizing and anxiety, social factors may also influence why breast cancer survivors may experience varying levels of pain during mammography. One potentially important social factor is social support. Within the literature, researchers have usually operationalized social support either as the quantity or the quality of support. Quantity of social support has typically been operationalized as the number of supportive others or interactions. To assess quantity, researchers have created measures that focus on 1) the size of the social support network (Pearson, 1986; Seeman & Berkman, 1988) and 2) the amount of varying types of support that a person

receives. Investigators have created questionnaires to measure instrumental/tangible support (i.e. help completing a task; Cohen, Mermelstein, Kamarck, & Hoberman, 1985; Shelbourne & Stewart, 1991), emotional support (i.e. encouragement, listening; Cohen et al, 1985; Flaherty, Gavaria, & Pathak, 1993; Shelbourne & Stewart, 1991), and informational support (i.e. providing information, advice giving; Barrera, Sandler, & Ramsay, 1981).

In contrast to objectively measuring the quantity of social support, the vast majority of research on social support in breast cancer survivor populations has instead focused on an individual's subjective perception of the quality of social support (Barrera, Sandler, & Ramsay, 1981; Broadhead, Elbach, de Gruy, & Kaplan, 1988; Zimet, Dahlem, Zimet, & Farley, 1988). Within breast cancer survivor populations, higher perceived quality of social support has been linked to less fatigue (Ferrell, Grant, Funk, Otis-Green, & Garcia, 1997), less depressive and anxiety symptoms (Green, Krupnick, Rowland, Epstein, Stockton, Spertus, et al., 2000), and less negative affect (Budin, 1998). Additionally, breast cancer survivors with higher perceived quality of social support also report higher quality of life (Beder, 1995; Sammarco, 2001, 2003), and have better immune function (Levy, Herberman, Lee, Whiteside, Kirkwood, McFeeley, 1990; Levy, Herberman, Whiteside, Sanzo, Lee, & Kirkwood, 1990) than survivors with lower perceived quality of social support.

With perceived quality of social support being important to so many aspects of breast cancer survivorship, it could be hypothesized that social support influences the mammography pain experience. A breast cancer survivor's perception of social support could be correlated with her mammography pain via a number of pathways. First, based on the hypothesis posited by Cohen & Wills (1985), social support is particularly important during a stressful event, and can buffer against stress-related negative outcomes. Since mammography can be viewed as a stressful event for breast cancer survivors, this hypothesis posits that survivors with higher perceived quality of social support may experience less pain during mammography than survivors with lower perceived support. Second, from the pain coping perspective, social support during a mammogram may function as an adaptive coping strategy. A supportive spouse may attend the mammography appointment with his wife, and provide distraction. Additionally, a survivor may perceive the technician administering the mammogram as more supportive if she offers suggestions for getting through the procedure. These pain coping techniques may be associated with less mammography pain. Third, perceived quality of social support may influence a survivor's affective state, by either reducing negative affect or increasing positive affect. A survivor who generally has higher perceived quality support may report less negative affect at the time of the mammogram than someone with less perceived quality of support. This reduced negative affect may be associated with less mammography pain. Fourth, social support may function via

operant learning, with a survivor's adaptive or maladaptive pain coping behaviors reinforced by the support network. For example, if the social network typically reinforces a survivor's catastrophizing about pain, she may report more pain during mammography. Finally, according to Reynolds and Perrin's matching hypothesis (2004), women may report higher perceived quality of social support if the type of support offered by the social network is what they actually wanted. So during mammography, if the technician offers informational support, but a survivor would have preferred emotional support, she may report lower perceived quality of social support. This lower perceived quality of support may then be associated with more pain during the procedure.

Empirical Support for Perceived Quality of Social Support

To date, the correlation between perceived social support and mammography pain for breast cancer survivors has not been assessed. However, a number of investigations have assessed the correlation between social support/social functioning and bodily pain in cancer survivors, including breast cancer survivors. The findings of these studies mostly support the hypothesis that higher levels of social support correlate with lower reports of pain (Ferrell et al., 1998; Kelsen, Portenoy, Thaler, Niedzwiecki, Passik, Tao et al., 1995; Rummans, Frost, Suman, Taylor, Novotny, Gendron et al, 1998; Spiegel, Sands, & Koopman, 1994; Strang 1992; Strang & Qvarner, 1990; Willey & Silliman, 1990). In one such study, Ferrell, Grant, Funk, Otis-Green, and Garcia (1998)

assessed social well-being and pain in 298 breast cancer survivors. Ferrell and colleagues used the QOL-Breast Cancer Version (Ferrell et al, 1998) to investigate social well being and physical well-being. The social well-being subscale consisted of a number of social factors including feelings of isolation caused by cancer and treatment, illness-related interference in social activities, support, sexuality, financial burden, family distress, and concern for female relatives. Pain was measured using a single item from the physical well-being subscale. The researchers conducted correlational analyses to determine if social well-being was correlated with pain reports.

Data analyses revealed a statistically significant relationship between social well-being and pain. More specifically, breast cancer survivors who reported higher social well-being reported significantly less pain than those with lower levels of social well-being ($r = .56, p < 0.05$). This study represents good preliminary evidence that social factors can correlate with pain in breast cancer survivors, but there were a few important limitations. First, the investigators focused on social well-being, a variable that included a variety of social factors. By using a global measure of social well-being, there is no way to determine which social factors may be driving the association with pain. Second, the researchers did not use any well-validated measures of pain, and instead used a pain item from the physical well-being subscale. Third, the researchers did not focus on a particular period of breast cancer survivorship, so it is difficult to discuss the implications the results may have on breast cancer survivors during particular periods

of survivorship. So overall, the Ferrell and colleagues study was a good preliminary investigation of social factors and breast cancer-related pain, but many questions still remained unanswered.

In an investigation with breast cancer and gynecologic cancer patients, Rummans, Frost, Suman, Taylor, Novotny, Gendron et al. (1998) evaluated social functioning and pain. The study sample included 64 breast cancer and 53 gynecologic cancer survivors who were diagnosed with recurrent cancer. To assess social functioning, the investigators used the MOS 36-item Short Form Health Survey (SF-36; Ware & Sherbourne, 1992). Pain was assessed using 3 items that assessed pain frequency, pain intensity, and pain interference with function. These 3 pain items were taken from the SF-36 and another measure of physical symptoms, the CARES Questionnaire (Schag & Heinrich, 1990).

Correlational analyses revealed statistically significant associations between social functioning and pain. Survivors reporting higher social functioning reported less pain intensity and interference, and less-frequent pain than survivors with lower social functioning (all p 's <0.001). These findings suggest that social functioning may be related to multiple aspects of the pain experiences of cancer survivors, and may even relate to the mammography pain experience.

This study by Rummans and colleagues (1998) addressed the timing limitation of the Ferrell et al (1998) investigation by focusing on women recently diagnosed with a

recurrence of cancer. Women with a recurrence of either breast or gynecologic cancer may experience unique psychosocial and physical challenges, so gaining more information about these factors may help researchers develop interventions tailored specifically for them. Second, although the researchers assessed the pain experience using 3 single-item measures of pain intensity, pain frequency, and pain interference, they did not use well-established pain measures. An additional limitation is the results for breast cancer and gynecologic cancer survivors were analyzed together. It would have been interesting to evaluate how the social functioning and pain of these two cancer populations compared to each other. A final limitation is that the use of a global social functioning score by Rummans et al. (1998) prevents one from evaluating which social factors (e.g. perceived quality of support, social network size) may be driving the association with pain intensity, frequency, or interference.

Kelsen, Portenoy, Thaler, Niezwiecki, Passik, Tao et al. (1995) also conducted an investigation of pain and social support with cancer survivors, and did assess the role of perceived quality of social support specifically. With a sample of 130 patients recently diagnosed with pancreatic cancer, the researchers evaluated perceived quality of social support and pain before the patients underwent cancer treatment (i.e. surgery or chemotherapy). To assess perceived quality of social support, the participants completed the perceived social support subscale of the Interpersonal Support Evaluation

List (Cohen, et al., 1985), a well-validated social support measure. Pain intensity was assessed using a pain VAS.

Correlational analyses revealed a statistically significant relationship between perceived quality of social support and pain intensity. Patients who reported higher levels of perceived quality of social support reported significantly less pain than patients with lower perceived quality of support ($r = -.281, p = .028$). Although this study was not conducted with breast cancer patients at the time of mammography, the findings suggest that perceived quality of social support may be an important factor of the pain experience for cancer survivors. This investigation had some strengths that are worth noting. First, unlike the study conducted by Ferrell et al. (1998), the researchers focused on a clinically-meaningful period of cancer treatment and survivorship, and presented evidence that interventions to increase perceived quality of social support may help alleviate pain in newly diagnosed cancer patients. Second, the researchers used well-established measures of the constructs of interest, and assessed perceived quality of social support for its unique relationship with cancer-related pain. Since perceived quality of social support has been found to correlate with so many physical and psychological cancer-related outcomes, further investigation of its association with pain is warranted.

Comment

Taken together, the findings suggest that social functioning/well-being appear to be important variables in cancer survivorship. The investigations reviewed tentatively suggest that higher social well-being/functioning correlates with lower pain reports in cancer patients. Additionally, the only investigation of perceived quality of social support found that higher perceived quality of social support was associated with less pain. These 3 investigations of social well-being and perceived quality of social support had some noteworthy methodological strengths. First, the studies conducted by Rummans et al. (1998) and Kelsen et al. (1995) focused on clinically meaningful periods of survivorship. Second, the only study to assess perceived social support and pain used well-established measures of those variables, lending more validity to its findings. However, these studies also had some limitations. Two of the investigations (Ferrell et al., 1997; Rummans et al., 1998) used a global measure of social functioning, which did not allow for the assessment of the unique relationship of perceived quality of social support and pain. Second, although two investigations included breast cancer survivors as participants (Ferrell et al, 1997; Rummans et al., 1998), they only assessed general cancer-related pain. By only assessing general cancer-related pain, it is unclear how applicable these results are to an acute pain experience, specifically mammography-related pain.

Although not conducted with breast cancer patients, findings from the clinical acute pain and experimental pain literatures help to make a stronger case for the importance of social support in the pain experience. A review conducted by Hodnett, Gates, Hofmeeyr, and Sakala (2003) for the Cochrane Database of Systematic Reviews found that in 11 trials that included 11,000 women during childbirth, women who had continuous social support during childbirth were less likely to be given analgesic medication than women who received usual care, suggesting they were having less pain. Higher perceived quality of social support has also been associated with less pain following coronary artery bypass surgery (Con, Linden, Thompson, & Ignaszewski, 1999; Kulik & Mahler, 1989). Additionally, in the experimental pain literature, researchers have manipulated the level of social support offered during a painful task, and have found that higher perceived social support was associated with increased pain tolerance (Brown, Sheffield, Leary, & Robinson, 2003). So collectively, studies of cancer pain, labor pain, and experimental pain all suggest that social factors, including higher perceived quality of social support may correlate with less mammography pain for breast cancer survivors.

1.2.2.6 Comment on Psychosocial Factors

Taken together, the findings of these investigations suggest that certain psychosocial factors may be important to the mammography pain experience. First, pain catastrophizing has been found to be an important variable in the pain experience.

The one study that investigated mammography-specific pain catastrophizing suggested that higher mammography-specific pain catastrophizing could be associated with more mammography pain. Second, anxiety is a common occurrence for breast cancer survivors, and may contribute to the pain experienced during mammography. Two investigations that were conducted at the time of breast cancer surgery suggested that higher anxiety and emotional distress may be associated with higher postoperative pain reports. Third, perceived quality of social support has been linked to a number of physical and psychological outcomes of breast cancer survivors, and may be associated with less mammography pain. The one investigation of perceived quality of social support and pain in cancer survivors indicated that higher perceived quality of social support may be associated with less pain.

While the majority of the reviewed investigations were not conducted to investigate the mammography pain experience of breast cancer survivors, they suggest that an assessment of these psychosocial variables at the time of mammography is warranted. Within pain coping, mammography-specific pain catastrophizing appears to be a promising variable to assess first, since one investigation suggested it to be more strongly predictive of mammography pain than day-to-day pain catastrophizing. Within affective states, the most promising avenue to assess first would be mammography-related anxiety. As stated earlier, breast cancer survivors have been found to report significantly more anticipatory anxiety and hyperarousal at the time of

mammography than healthy women (Gurevich et al., 2004). Second, in the investigation conducted by Katz et al. (2005) anxiety was the only negative affective state that predicted postoperative pain in breast cancer survivors. Within social support, perceived quality of social support would be the most promising variable to assess at the time of mammography. Perceived social support has been linked to many physical and psychological variables in breast cancer survivors. Additionally, higher perceived quality of social support was associated with less pain in pancreatic cancer patients. So overall, pain catastrophizing, anxiety, and perceived quality of social support should all be assessed for their associations with mammography-related pain.

If assessment of these psychosocial factors at the time of mammography suggests associations with mammography pain, psychosocial interventions could prove helpful before and during the mammography. For example, interventions could be designed to teach adaptive pain coping skills, with the goals of: 1) increasing the use of active pain coping skills and 2) reducing the use of pain catastrophizing. Evidence from the chronic pain and experimental pain literatures indicate that both multi- and single-session pain coping interventions can significantly reduce reported pain (Carson, Keefe, Affleck, Rumble, Caldwell, Beaupre, et al., 2006; Emery, Keefe, France, Affleck, Waters, Fondaw, et al., 2006; Keefe, Blumenthal, Baucom, Affleck, Waugh, Caldwell, et al., 2004). Brief 1-session pain coping skills interventions could be designed to be administered immediately before a mammography appointment. A brief pain coping skills

intervention could include providing survivors with a number of pain coping skills that they could perform during the procedure including breathing relaxation, imagery, calming self-statements, reinterpreting the pain sensations, mental counting, and focusing on physical surroundings (Gil, Carson, Sedway, Porter, Schaeffer, & Orringer, 2000). Alternatively, researchers could create a comprehensive pain coping skills intervention to be conducted over a 4-session period in the month leading up to a mammogram. In these sessions, survivors could be educated on the link between pain coping and pain intensity, along with the associations between specific pain coping techniques and pain. These sessions could also include practicing adaptive pain coping skills, and allowing for survivors to determine which skills might work best for them. These two types of pain coping interventions could allow breast cancer survivors to perceive more control over the mammography pain experience, which could be associated with lower reports of pain catastrophizing and less mammography pain.

Psychosocial interventions could also target the affective states of breast cancer survivors at the time of mammography. Decreasing anxiety at the time of mammography may be particularly important since preoperative anxiety was found to predict postoperative pain in breast cancer survivors. Cognitive behavioral interventions can be implemented with the goals of 1) reducing mammography-related anxiety and/or 2) increasing positive affect. To decrease mammography-related anxiety and arousal, a brief intervention could be conducted before a breast cancer survivor's

scheduled mammogram, and could include education on noticing feelings of anxiety and arousal, and practicing effective techniques for reducing arousal, including progressive muscle relaxation, paced respiration, meditation, and diaphragmatic breathing. If conducted over a series of sessions, breast cancer survivors would have an opportunity to practice the techniques. Progressive muscle relaxation training has been found to effectively reduce self-reported anxiety (Cheung, Molassiotis, & Chang, 2003; Rausch, Gramling, & Auerbach, 2006; Wachelka & Katz, 1999) and has also been found to be associated with decreases in salivary cortisol levels (a stress-response hormone; Pawlow & Jones, 2005). Meditation has been investigated with chronic pain and experimental pain populations, with results suggesting meditation practice may reduce reported pain (Astin, 2004; Gardner-Nix, Backman, Barbati & Grummitt, 2008; Wachholtz & Pargament, 2008).

Finally, psychosocial interventions could also be created with the goal of increasing a breast cancer survivor's perceived quality of social support. By increasing a survivor's level of perceived social support, she may then experience less mammography pain. One way to increase perceived quality of social support would be to involve a member of a survivor's social network in the interventions described above that target pain coping or negative affect. A supportive other would be learning the same techniques as the survivor, and would be taught how to provide effective encouragement and reinforcement to her. A number of interventions have used partner-

assisted programs to teach skills or change behavior including coping skills training (Campbell, Keefe, Scipio, McKee, Edwards, Herman, et al., 2007; Keefe et al., 2004), smoking cessation programs (McBride, Baucom, Peterson, Pollack, Palmer, Westman, et al., 2004). A brief partner-assisted program could be conducted the day of the mammogram in a few ways. First, breast cancer survivors could be asked to bring a member of their support network with them to the mammography appointment, and the dyad could learn a brief pain coping skills to be conducted during the procedure including imagery, calming self-statements, reinterpreting the pain sensations, mental counting, and focusing on physical surroundings. Second, before the mammogram, breast cancer survivors and a supportive other could learn the techniques for reducing negative affect or increasing positive affect including progressive muscle relaxation, paced respiration, diaphragmatic breathing, and watching a positive video. If these interventions were expanded to a multiple-session model, the survivor-supporter dyads could then practice the skills within the sessions, and additionally could be asked to practice learned techniques outside the context of the sessions. Having a survivor-support other dyad attend multiple sessions may promote higher levels of perceived quality of social support, which then on the day of mammography, may be associated with less pain.

1.2.3 Biological and Psychosocial Factors in Mammography Pain: Toward a Biopsychosocial Model of Mammography Pain

This review has presented factors that may individually impact the mammography pain experiences of breast cancer survivors. However, investigations that focus more broadly on quality of life in women with breast cancer suggest that survivors experience a number of these biological and psychosocial challenges simultaneously, and that many of these factors may be intercorrelated (Carver, Smith, Antoni, Petronis, Weiss, Derhagopian, 2005; Leak Hu, King, 2008; Manne, Ostroff, Winkel, Grana, Fox, 2005; Roth, Lowery, Davis, Wilkins, 2005). So, while a woman may be experiencing many of these challenges of survivorship at the time of mammography, it is unclear how these factors may simultaneously influence her mammography pain experience. A biopsychosocial approach to investigating mammography pain would provide a framework by which biological and psychosocial factors could be simultaneously considered for their individual and collective associations with mammography pain. A biopsychosocial model would be informative in a number of ways. First, it would encourage researchers studying mammography pain to consider the multiple biological and psychosocial variables that could influence pain at the time of mammography. Second, it would provide the framework for statistical analyses that partial out the relative importance that individual biological, psychological, and social factors have on mammography pain. For example, analyses could determine if ongoing

breast pain is more strongly associated with higher mammography pain than is mammography-related anxiety. Third, by using mediation analyses, a biopsychosocial approach would allow for a researcher to explore how these challenges relate to mammography pain either directly or indirectly. An example would be to assess if mammography-related anxiety mediates the relationship between quality social support and higher mammography pain.

The present study explored the utility of a biopsychosocial model of mammography pain. The formulation of this model was based on prior research and hypothesized associations between ongoing breast pain, mammography-related anxiety, social support, mammography-related pain catastrophizing, and mammography pain.

The following hypotheses were tested:

1.2.3.1 Ongoing Breast Pain Hypotheses

- Higher ongoing breast pain will be directly associated with higher mammography pain.
- Higher ongoing breast pain will be indirectly associated with higher mammography pain through mammography-related anxiety, with those reporting higher ongoing breast pain and higher anxiety reporting the highest mammography pain.
- Higher ongoing breast pain will be indirectly associated with higher mammography pain through mammography-related pain catastrophizing, with

those reporting higher ongoing breast pain and higher catastrophizing reporting the most mammography pain.

1.2.3.2 Social Support Hypotheses

- Lower perceived quality and quantity of social support will be directly associated with higher mammography pain.
- Lower perceived quality and quantity of social support will be indirectly associated with higher reported mammography pain through mammography-related anxiety, with those lower support and higher anxiety reporting the most mammography pain.
- Lower perceived quality and quantity of social support will be indirectly associated with higher mammography pain through mammography-related pain catastrophizing, with those reporting lower support and higher catastrophizing reporting the most mammography pain.

1.2.3.3 Mammography-Related Anxiety Hypothesis

- Higher mammography-related anxiety will be directly associated with higher mammography pain.

1.2.3.3 Mammography-Related Pain Catastrophizing Hypothesis

- Higher mammography-related pain catastrophizing will be directly associated with higher mammography pain.

The model investigated was one that explored all potential direct associations between mammography pain and all explanatory factors presented. The hypothesized model also explored potential indirect associations. Figure 3 illustrates this model. Within the model, ongoing breast pain, social support quality, and social support quantity were specified as exogenous variables. Mammography-related pain catastrophizing and mammography-related anxiety were specified as intervening endogenous variables. Mammography pain was specified as the dependent variable. Error terms were also presented for the intervening endogenous variables (e.g. mammography-related anxiety and pain catastrophizing) and for mammography pain.

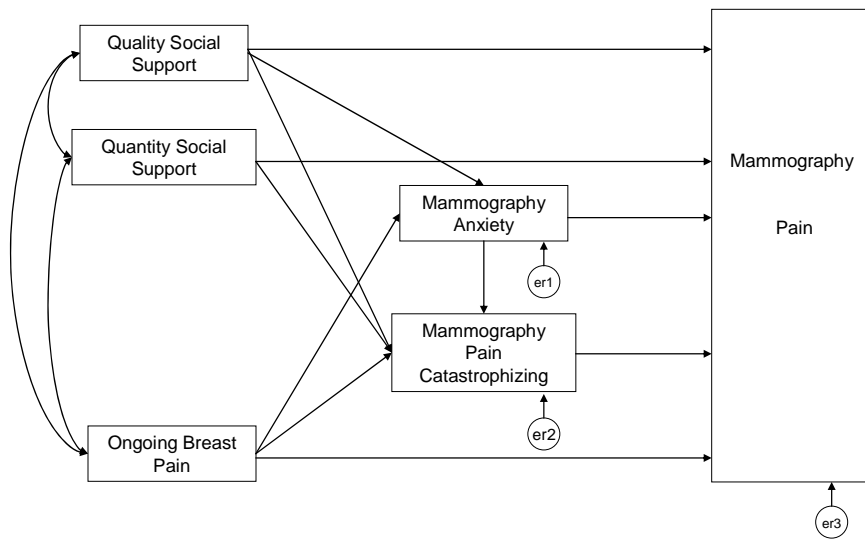


Figure 3: Anticipatory Anxiety, Pain Catastrophizing, and Perceived Low Quality Social Support Stimulating Mammography-Related Pain

2. Method

2.1 Method Overview

Figure 4 provides an overview of the study design. In the current investigation, early-stage breast cancer survivors who were scheduled to undergo mammography completed questionnaires assessing ongoing breast pain, anticipatory anxiety, social support, demographic information, and medical history immediately before and mammography pain and mammography-related pain catastrophizing immediately after their scheduled mammograms.

Several features of the current study are noteworthy. First, the current investigation was the first to investigate the utility of a comprehensive biopsychosocial model of the mammography pain experiences of breast cancer survivors. Although a few investigations have previously examined how one biological or psychosocial factor may individually relate to pain during mammography, little is known about how these factors may uniquely correlate with mammography pain when controlling for other variables in the model or how factors indirectly relate to mammography pain. Second, the current study investigated breast cancer survivorship well beyond the initial cancer treatment period, by including survivors who are up to 10 years post-treatment. This feature is particularly important as survival rates for breast cancer increase, and women are living for more years as survivors. Third, the current investigation was conducted at the time of a routinely scheduled mammogram appointment. This is a highly salient

event for survivors of breast cancer. Additionally, during these pre-scheduled mammography appointments, breast cancer survivors usually having waiting periods before and after the procedure, during which they can feasibly complete the battery of measures.

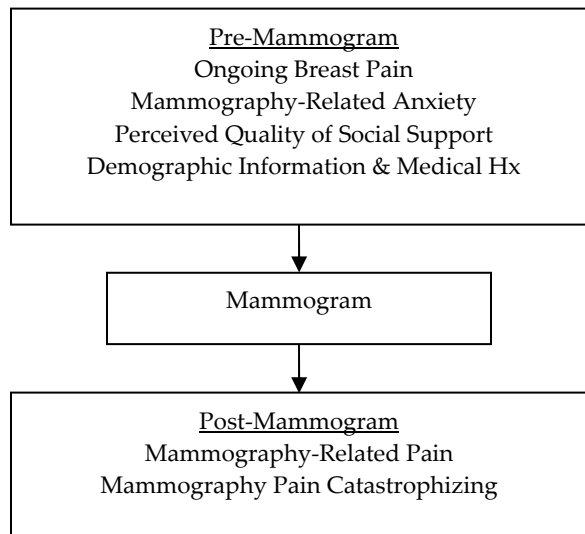


Figure 4: Study Design Overview

2.2 Sample

This study included women diagnosed with early-stage breast cancer who met the following inclusion criteria: (a) ≥ 18 years old (b) a diagnosis of Stage I-IIIa breast cancer as ascertained through medical records (c) ≤ 10 years since diagnosis with breast cancer (d) post-lumpectomy treatment for breast cancer, (e) receiving follow-up mammography at Duke University Medical Center, (f) can speak and read English, and (g) cognitively capable of providing consent for participation.

2.3 Procedure

Eligibility was established through medical records review. Prospective participants were contacted by letter at least two weeks prior to the date of a scheduled mammogram. This contact letter stated that they were eligible to participate in a one-time research study assessing their experiences with mammography. In the letter, the prospective participants were provided with a phone number and email address of study staff to use if they preferred not to be approached about the study in the mammography clinic. Prospective participants who did not decline were then approached in the mammography clinic and provided with an explanation of the study. Consenting participants were then enrolled.

2.4 Measures

Participants were given questionnaires to complete 1) immediately prior to mammography and 2) immediately following mammography.

2.4.1 Pre-Mammogram Measures

The pre-mammogram questionnaires included (a) a demographic information and cancer treatment history questionnaire; (b) an ongoing breast pain questionnaire; (c) a questionnaire assessing mammography-related anticipatory anxiety; and (d) a perceived quality of social support questionnaire.

2.4.1.1 Demographic Information and Cancer Treatment History

Study participants reported their age, race/ethnicity, current marital status, education, current employment status, household income, breast cancer treatment history (i.e. date of diagnosis, surgical history, hormone therapy, chemotherapy, and/or radiation), and menstrual cycle status. Medical records were also reviewed in order to determine if participants developed lymphedema following cancer treatment.

2.4.1.2 Ongoing Breast Pain

Ongoing breast pain was measured using a modified version of the Brief Pain Inventory (BPI; Cleeland, 1985; Daut, Cleeland, & Flannery, 1983). Using a numerical rating scale ranging from 0 (no pain) to 10 (pain as bad as it can be), participants rated the following: their worst breast pain in the past week, their least breast pain in the past week, their average breast pain in the past week, and their current breast pain. The BPI has been shown to be a reliable and valid instrument in a number of investigations conducted with cancer and non-cancer patient populations, with Cronbach's alphas ranging from .86 to .96 (Cleeland, Gonin, Hatfield, Edmonson, Blum, Stewart, et al., 1994; Keller, Bann, Dodd, Schein, Mendoza, & Cleeland, 2004; Klepstad, Loge, Borchgrevink, Mendoza, Cleeland, & Kaasa, 2002; Reyes-Gibby, Ba Duc, Phi Yen, Hoai Nga, Van Tran, Guo, et al., 2006). In the current investigation, the modified BPI had a Cronbach's alpha value of .92. In addition to pain intensity participants also answered questions regarding the length of time they have experienced breast pain, how often

they experience breast pain, and if they experienced breast pain prior to their breast cancer diagnosis.

2.4.1.3 Mammography-Related Anxiety

The Stanford Acute Stress Reaction Questionnaire (SASRQ; Cardena, Koopman, Classed, Waelde, & Spiegel, 2000) is a 30-item measure used to assess an acute stress reaction (i.e. hyperarousal, dissociation, intrusion, and avoidance) to a given stressor. In the current investigation, participants completed a 27-item modified version of the SASRQ that evaluated mammography-related anticipatory anxiety. Using a numerical rating scale from 0 (not experienced) to 5 (very often experienced), participants rated how often they experienced specific symptoms during the week prior to the mammogram. The original SASRQ has been found to have good reliability, with Cronbach's alphas ranging from .8 to .95 (Cardena, et al., 2000), and has been previously administered to a breast cancer survivor population at the time of mammography (Gurevich, Devins, Wilson, McCready, Marmar, & Rodin, 2004). For the current study, the Cronbach's alpha value for the modified SASRQ was .97.

2.4.1.4 Social Support

Social support was measured using the Inventory of Socially Supportive Behaviors (ISSB; Barrera, Sandler, & Ramsay, 1981). The ISSB is a 40-item measure that was used to evaluate the social support the breast cancer survivors received from their social networks. For the current investigation, participants completed a modified

version of the ISSB that captured quantity and perceived quality of social support. For each of the 40 items, participants answered “yes” or “no” to each of two questions: a) if an activity occurred within the past 4 weeks, and b) did they want the activity to occur. This modification in the ISSB has been previously administered with a breast cancer population, with mismatches in support being positively correlated with worse psychosocial adjustment to breast cancer (Reynolds & Perrin, 2004). Mismatches in social support were defined as either 1) wanting support but not receiving it, or 2) not wanting support but receiving it. The participants also answered 3 items that assessed their level of satisfaction with the guidance support, emotional support, and tangible support they received within the past 4 weeks. The ISSB has been shown to have good test-retest reliability (.88) and internal consistency, with a Cronbach’s alpha of .92- .94 (Barrera & Ainlay, 1983; Barrera, et al., 1981). For the current study, the Cronbach’s alpha value was .93 for social support quantity subscale. Since mismatches in social support were measured with a dichotomous yes/no scale, the Kuder-Richardson Formula 20 (KR-20) value was used to assess internal consistency of the support mismatches subscale. The KR-20 value was .89. A quality social support composite score was created using the guidance, emotional, and tangible social satisfaction items, along with a reverse score for mismatches in social support.

2.4.2 Post-Mammogram Measures

After the participants underwent mammography, they completed the post-mammogram questionnaires including (a) a questionnaire assessing mammography-related pain, and (b) a measure of mammography-related pain catastrophizing.

2.4.2.1 Mammography Pain

A modified version of the BPI was also used to assess mammography-related pain. Using a numerical rating scale ranging from 0 (no pain) to 10 (pain as bad as it can be), participants rated: worst pain during the mammogram, least pain during the mammogram, average pain during the mammogram, present pain, and pain during previous mammogram. As mentioned above, the BPI has been shown to have excellent internal consistency.

2.4.2.2 Mammography-Related Pain Catastrophizing

Participants rated their mammography-related pain catastrophizing (i.e. pain rumination, pain magnification, and helplessness) using the 13-item Pain Catastrophizing Scale (PCS; Sullivan, Bishop, & Pivik, 1995). For each item, participants indicated the degree to which they experienced thoughts and feelings about mammography-related breast pain on a 5-point numerical rating scale ranging from 0 (not at all) to 4 (all the time). The PCS has been found to have good internal consistency, with Cronbach's alphas ranging from .87 to .95, and has been administered to a variety of populations including patients and healthy volunteers (Osman, Barrios, Gutierrez,

Kopper, Merrifield, & Gritman, 2000; Sullivan et al., 1995). For the current study, the Cronbach's alpha value was .94.

2.5 Data Analyses and Sample Size Determination

2.5.1 Overview

Correlational and linear path model analyses were conducted in order to investigate how biological and psychosocial factors relate to mammography pain of breast cancer survivors. First, a correlation matrix was created to evaluate if demographic factors (i.e. age, marital status, race, household income, education), and/or cancer treatment history (i.e. lymphedema, chemotherapy, radiation therapy, time since breast cancer surgery), correlate with mammography pain at the $p \leq 0.05$ significance level. If any of these variables were found to significantly correlate with mammography pain, they were controlled for in subsequent analyses.

2.5.2 Path Analysis

Second, a linear path model analyses, which provides simultaneous path estimation and indices of model-data fit, were conducted to assess the hypothesized direct and indirect relationships between ongoing breast pain, pain catastrophizing, anticipatory anxiety, social support, and mammography pain. Figure 3 represents the full path model to be tested. Within path model analyses, ongoing breast pain, social support quality and social support quantity were specified as exogenous variables. Mammography-related pain catastrophizing and mammography-related anxiety were

specified as intervening endogenous variables. Mammography pain was specified as the dependent variable. The direct pathways between ongoing breast pain, pain catastrophizing, anticipatory anxiety, social support, and mammography pain were examined first. Path estimates that were statistically significant ($p \leq 0.05$) from ongoing breast pain, pain catastrophizing, anticipatory anxiety, and social support to mammography pain indicated a direct relationship with mammography pain. Next, the indirect effects of ongoing breast pain, anticipatory anxiety, and social support (quantity and quality) on mammography pain were examined. Estimates of indirect effects were obtained from the path model and the significance of indirect relationships was assessed using the Sobel test (Sobel, 1982). To avoid structural multicollinearity and reduce Type II error, the path model was trimmed if exogenous and intervening endogenous variables had a path coefficient $\geq .5$ (Cohen, Cohen, West, & Aiken, 2003; Grewal, Cote, & Baumgartner, 2004).

Several advantages of conducting path analysis are noteworthy. First path analysis represents simultaneous regression equations, and conducting these analyses simultaneously reduces Type I error. Second, path analysis allows for indirect relationships between biological and psychosocial factors and mammography pain to be assessed. This characteristic allows for more complicated relationships to be investigated than would be possible using simpler multiple regression analyses. Finally, path analysis provides indices of overall model-data fit. Model fit will be assessed using the root mean square error of approximation (RMSEA) and Bentler's comparative fit

index (CFI), as calculated by AMOS 7.0 statistical software. RMSEA is a measure of the amount of approximation error in the proposed model. Kline (1998) recommends considering RMSEA values of $p \leq .05$ as indicating close fit, values of $p = .05-.08$ as indicating reasonable error of approximation, and values of $p > .10$ as indicating poor model fit. Bentler's CFI assesses the relative improvement in fit of the proposed model compared to the null model. In this instance, the null model assumes zero population covariances among the variables. CFI values greater than .90 are generally considered to indicate adequate fit of the proposed model (Byrne, 2001; Kline, 1998).

Exploratory moderated mediation analyses were also conducted to further investigate statistically significant indirect effects on mammography pain. These moderated mediation analyses tested if the indirect effect of a predictor on mammography pain was consistent across varying levels of that predictor (Preacher, Rucker, & Hayes, 2007). For example, if ongoing breast pain had a statistically significant indirect effect on mammography pain via pain catastrophizing, moderated mediation analyses tested whether this indirect effect was consistent at different levels of ongoing breast pain (e.g. at higher vs. lower levels of ongoing breast pain).

To determine sample size for the current investigation, two methods were utilized. First, according to Kline (1998), in order to adequately assess significance within a path model, 10 participants should be included for each parameter within the path model. More specifically, 10 participants should be included for each path coefficient in the model, including path coefficients for error terms. For the proposed

model, that recommendation would suggest 140 participants. Second, power analyses were conducted using RMSEA. RMSEA was chosen to determine power and sample size because it is a measure of discrepancy per degree of freedom and allows for a non-central chi-square distribution. Using RMSEA, power analyses were conducted in order to determine the number of participants that would be necessary in order to detect a significant difference between a close-fitting path model (RMSEA $p = 0.05$) and a poorer-fitting path model (RMSEA $p = .10-.15$). Power was determined for models with 3 control variables. The number of control variables that may be controlled for in the model was considered for a few key reasons. First, conceptually, it could be hypothesized that a number of cancer treatment-related factors (i.e. time since surgery, history of chemotherapy, radiation, lymphedema) may be related to mammography pain, and should be controlled for within the model. Second, it is unknown if demographic variables (i.e. education, household income, race, ethnicity) are related to mammography pain. If any of these cancer treatment-related and/or demographic variables are found to correlate with mammography pain in the bivariate correlation analyses, they will be included in the path model. Based on past literature, time since surgery, and a history of radiation or lymphedema will be included as control variables, and power analyses were conducted with the anticipation of needing to control for at least these 3 variables. Thus, power analyses were conducted in order to determine the number of participants that would be necessary in order to detect a significant difference between a close-fitting path model (RMSEA $p = 0.05$) and a poorer-fitting path model

(RMSEA $p = 0.10-0.15$) with 3 control variables included. Table 1 represents the results of these power analyses based on RMSEA. Based on these factors, a sample size of 130 participants was chosen.

Table 1: Sample Sizes Needed for Power = 0.80, $\alpha = 0.05$, $H_0 p = 0.05$, $df = 31$, and $H_{alt} p = 0.10-0.15$

$H_{alt} p$ values	0.10	0.11	0.12	0.13	0.14	0.15
N	133	100	78	64	53	45

3. Results

3.1 Demographic Information and Cancer Treatment History

Early stage breast cancer survivors (stages I-III A) who had undergone lumpectomy were sent recruitment letters 2 weeks prior to their follow-up mammography appointment at Duke University Medical Center. Of the 147 who were approached to participate, 127 were enrolled in the current study. The mean age for the final sample was 60 years ($SD = 11.12$), and the sample was 85.6% Caucasian and 12.6% African-American. Approximately 72.4% of the sample was married. The mean number of years of education was 14.8. Approximately 45.7% of the sample was retired and 39.4% was employed. The majority of women (56.4%) reported a household income greater than \$60,000. Table 2 presents the sample demographic characteristics.

Table 2: Demographic Characteristics

Variable	Percentage	Mean (SD)	Range
Age		60 years (11.1)	35-86
Race			
Caucasian	85.8		
African American	12.8		
Not reported	1.6		
Marital Status			
Married	72.4		
Widowed	10.2		
Divorced	8.7		
Single	4.7		
Separated	1.6		
Not reported	2.4		
Years of Education		14.8 years (2.5)	6-20
Employment Status			
Retired	45.7		
Working	39.4		
Unemployed	12.6		
Not reported	2.4		

Table 3 continued: Demographic Characteristics

Variable	Percentage		
Household Income			
Above \$60,000	48.8		
\$40,001-60,000	15.0		
\$18,000-40,000	17.3		
Below \$18,000	5.6		
Not reported	13.4		

With regard to cancer-related variables, the mean number of years since cancer diagnosis was 5.14 ($SD = 2.34$), and 57.4% had stage I breast cancer, 39.4% had stage II breast cancer, and 3.2% had stage III breast cancer. The majority of women (83.5%) received hormonal therapy, 45.7% received chemotherapy, and 92.9% received radiation therapy. Approximately 87.4% of the sample reported that their menstrual periods had stopped. Table 3 summarizes cancer diagnoses and treatment characteristics for the study sample.

The means, standard deviations, and ranges for mammography pain, ongoing breast pain, pain catastrophizing, mammography-related anxiety, and social support are presented in Table 4. On average, the participants reported moderate levels ($M=5.19$ on a 0-10 scale) of mammography pain, which was slightly higher than was found in previous studies of mammography pain for breast cancer survivors (Ashghari & Nicholas, 2004; Kornguth et al., 2000). Although average ongoing breast pain,

mammography-related pain catastrophizing, mammography-related anxiety, social support quantity, and mismatches in social support were in the lower range (similar to findings from previous investigations of these factors in breast cancer populations) the standard deviations on these measures were relatively large (greater than the mean) suggesting that participants varied substantially in these measures. Social support quality, including emotional, guidance, and tangible support satisfaction, was rated as high on average.

Table 4: Cancer Diagnosis and Treatment History Characteristics

Variable	Percentage	Mean (SD)	Range
Time since diagnosis		5.1 years (2.3)	2-10
Cancer stage			
IA-IB	57.4		
IIA-IIB	39.4		
IIIA	3.2		
Cancer treatment			
Lumpectomy	100.0		
Radiation therapy	92.9		
Hormonal therapy	83.5		
Chemotherapy	45.7		
No longer menstruating	87.3		
Lymphedema since treatment	17.3		

Table 5: Cancer Diagnosis and Treatment History Characteristics

Variable	Mean (SD)	Range
Mammography Pain	5.19 (2.64)	0.0-10.0
Ongoing Breast Pain	1.26 (1.92)	0.0-8.0
Mammography-Related Pain Catastrophizing	5.75 (8.53)	0.0-49.0
Mammography-Related Anxiety	17.26 (22.91)	0.0-127.0
Social Support Quality	13.68 (3.06)	1.49-17.33
Emotional support satisfaction	3.11 (1.02)	0.0-4.0
Guidance support satisfaction	2.96 (1.03)	0.0-4.0
Tangible support satisfaction	3.02 (0.99)	0.0-4.0
Mismatches in support	2.90 (5.85)	0.0-40.0
Social Support Quantity	15.89 (9.32)	0.0-40.0

3.2 Preliminary Analyses

Prior to conducting path analyses, bivariate correlations among the variables were explored. The results of these intercorrelations are presented in Table 5. First, in examining the results, all of the associations were in the expected direction, and many were significant (0.05). Bivariate correlations were also conducted to investigate if demographic variables and/or cancer treatment history factors should be included as

covariates in subsequent analyses. Demographic variables included age, race/ethnicity, current marital status, education, current employment status, and household income. Cancer treatment variables included time since cancer diagnosis, hormone therapy, chemotherapy, radiation, menstrual cycle status, and history of lymphedema. Correlational analyses revealed that younger age was significantly correlated with higher mammography pain, higher mammography-related pain catastrophizing, and higher mammography-related anxiety. For this reason, age was included in later analyses. No other demographic or cancer treatment factors were significantly correlated with mammography pain, and therefore, no other covariates were included in subsequent analyses.

3.3 Testing the Fit of the Hypothesized Model

To investigate the hypothesized biopsychosocial model of mammography pain, the overall fit of the full model presented in Figure 3 was tested. In addition to the paths identified in the figure, age was included as a covariate with paths drawn between: 1) age and mammography pain, 2) age and mammography-related anxiety, and 3) age and mammography-related pain catastrophizing. Although the fit indices suggested good fit (CFI = 1.00, RMSEA = 0.00), the standardized regression weight between mammography-related anxiety and mammography-related pain catastrophizing was very large ($\beta = 0.57$), suggesting that the two variables were highly correlated. To avoid structural multicollinearity and reduce Type II error, two different

Table 6: Intercorrelations Among Ongoing Breast Pain, Mammography-Related Pain Catastrophizing, Mammography-Related Anxiety, Social Support, and Mammography Pain

Variable	1	2	3	4	5	6	7	8	9
1. Ongoing Breast Pain	---								
2. Mammography-related Pain Catastrophizing	0.454**	---							
3. Mammography-related Anxiety	0.298**	0.635**	---						
4. Social Support Quality	-0.128	-0.360**	-0.307**	---					
5. Social Support Mismatch	0.153	0.337**	0.243**	-0.606**	---				
6. Emotional Support Satisfaction	-0.175	-0.330**	-0.334**	0.886**	-0.479**	---			
7. Guidance Support Satisfaction	-0.087	-0.304**	-0.315**	0.868**	-0.386**	0.770**	---		
8. Tangible Support Satisfaction	-0.109	-0.134	-0.085	0.750**	-0.248*	0.515**	0.520**	---	
9. Social Support Quantity	0.134	0.193*	0.260**	0.304**	-0.183	0.300**	0.227*	0.273*	---
10. Mammography Pain	0.195*	0.443**	0.344**	-0.276**	0.193*	-0.181	-0.280**	-0.062	0.172

* $p < .05$, ** $p < .01$

statistical approaches were considered in order to simplify the model.

The first approach assessed the utility of combining the mammography-related pain catastrophizing and mammography-related anxiety into one measure of mammography-related distress. This was done by first conducting a factor analysis of the items on the Pain Catastrophizing Scale (PCS; Sullivan et al., 1995) and the Stanford Acute Stress Response scale (SASRQ; Cardeña et al., 2000) to assess if the individual items on these measures would load on one factor of 'mammography-related distress.' For this factor analysis, the maximum likelihood method was used, with a 1-factor model specified. Within these results, 6 factors obtained Eigenvalues that were greater than or equal to 1.0, which suggests that a 6-factor design may be appropriate. The scree plot also suggested that 6 factors would be a suitable cutoff. Within the factor analysis, Factor 1 accounted for 51.88 % of the variance, however the Chi-squared analysis of a 1-factor model was significant ($\chi^2/df = 3.31, p < 0.001$), indicating that more than one factor would be needed to account for the variance in the data. A review of the item communalities also showed that several items (18 of 39 items) on the PCS and SASRQ obtained communality scores that were less than .5. This suggests that these items are exhibiting a high level of unique variance and the single factor scale was not adequately capturing item variability. Taken together, the results of the factor analysis suggested that the items on the PCS and SASRQ loaded on several factors and combining the scales would not simplify the model.

In an alternative approach for addressing multicollinearity, the original path model presented in Figure 3, and two competing models were tested: 1) a trimmed path model with mammography-related anxiety only (pain catastrophizing excluded) and 2) a trimmed path model with mammography-related pain catastrophizing only (anxiety excluded). The results of these two trimmed models are presented in Figures 5 and 6, respectively. These two models yielded drastically differing results. In the first model, where mammography-related anxiety was included, model fit indices continued to suggest good fit (CFI = 1.00, RMSEA = 0.00). However, in this model the only variable that significantly related to mammography pain directly is ongoing breast pain. This is in contrast to the bivariate correlations conducted earlier that suggested that lower quality social support, and higher mammography-related anxiety were significantly related to higher mammography pain. This first trimmed model also restricted the ability to explore if quality social support, quantity social support, and/or ongoing breast pain related to mammography pain indirectly because the path between mammography anxiety and mammography pain was not significant.

For the second trimmed model with mammography pain catastrophizing included, model fit indices also suggested good fit (CFI = 1.00, RMSEA = 0.00). However, the results differed from the previous model in a number of ways. First, the results suggested that lower quality social support, higher quantity social support, and higher ongoing breast pain all significantly related to higher mammography pain

catastrophizing (p 's ≤ 0.05). Second, the results showed that higher mammography pain catastrophizing significantly related to higher mammography pain directly ($p \leq 0.001$). Third, because of the significant path between mammography pain catastrophizing and mammography pain, the indirect effects of ongoing breast pain, quality social support, and quantity social support were able to be evaluated. The Sobel test for ongoing breast pain's indirect effect suggested that higher ongoing breast pain was significantly related to higher mammography pain through pain catastrophizing ($Z = 2.40, p = 0.02$). The Sobel test for quality social support's indirect effect suggested that lower quality social support was significantly related to higher mammography pain through pain catastrophizing ($Z = -2.64, p = 0.008$). The Sobel test for quantity social support's indirect effect on mammography pain was not significant ($Z = 1.71, p = 0.09$).

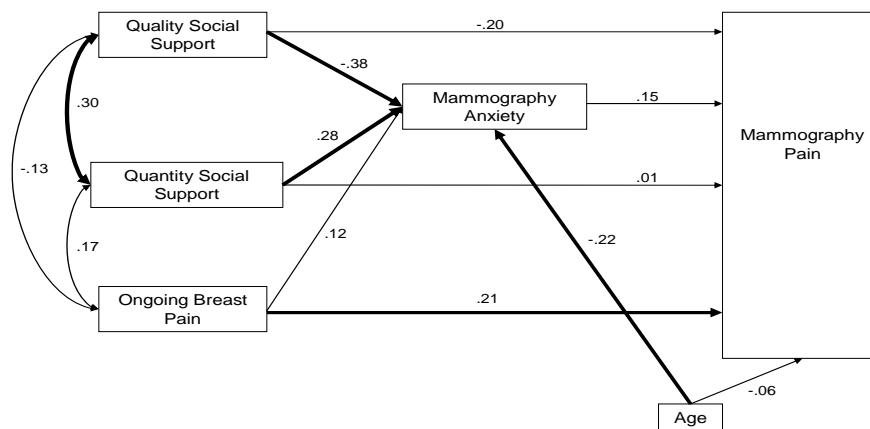


Figure 5: Trimmed Path Model Excluding Catastrophizing

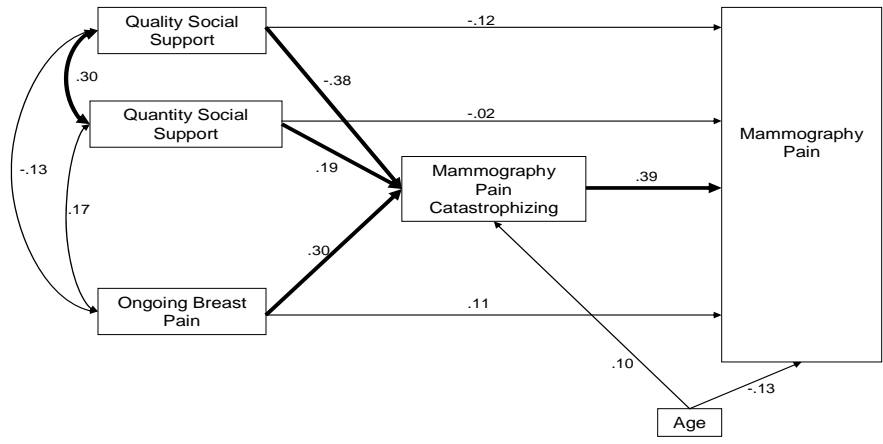


Figure 6: Trimmed Path Model Excluding Anxiety

3.4 Post-Hoc Analyses

In order to further investigate the statistically significant indirect effects of ongoing pain and quality social support that were suggested in the second trimmed path model, moderated mediation analyses were conducted. These moderated mediation analyses tested if the indirect effect of a predictor on mammography pain was consistent across varying levels of that predictor (Preacher, Rucker, & Hayes, 2007).

3.4.1 Ongoing Breast Pain

The first analysis tested if the indirect effect of ongoing breast pain on mammography pain was consistent across varying levels of ongoing breast pain.

Results showed that the moderated mediation effects were not significant ($p = 0.20$), indicating that the indirect effects were consistent across levels of ongoing breast pain.

3.4.1 Quality Social Support

Analyses were also conducted to assess if the indirect effect of quality social support on mammography pain was consistent across varying levels of quality social support. Results showed that the moderated mediation effects were significant ($p \leq 0.01$), indicating that the indirect effects of quality social support on mammography pain were significantly different at varying levels of quality social support. Specifically, the mediation effects of pain catastrophizing on mammography pain were more pronounced at higher levels of quality social support than for lower quality support. The results are presented in Figure 7.

In the prior path modeling and moderated mediation analyses, a quality social support composite score was used. To further explore the potential relationships between different types of social support and mammography pain, the individual support components were assessed independently. The components assessed were emotional social support satisfaction, guidance social support satisfaction, and mismatches in social support. Since tangible social support satisfaction was not correlated with mammography pain in bivariate correlations, it was excluded from additional analyses. Path analyses were conducted by replacing quality social support

with either emotional social support satisfaction, guidance social support satisfaction, or mismatches in social support using the trimmed model presented in Figure 6.

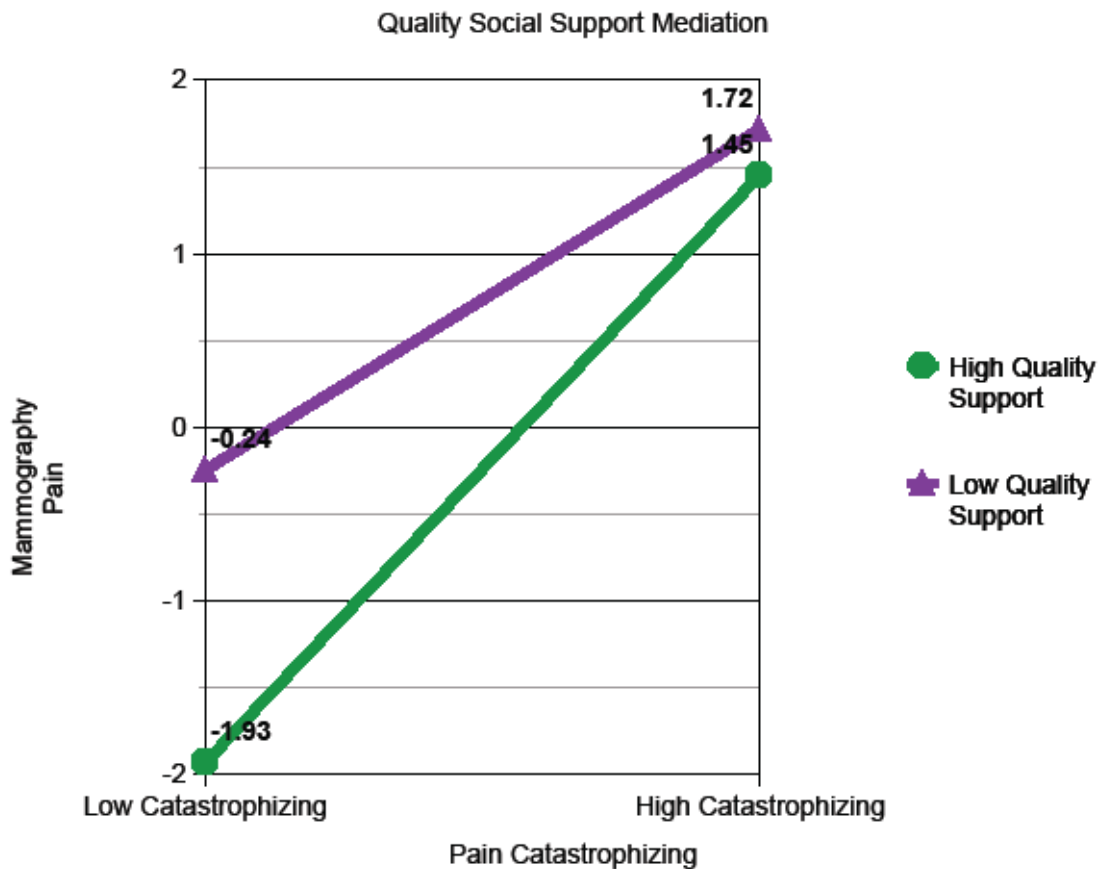


Figure 7: Quality Social Support Mediation

3.4.2.1 Emotional Support Satisfaction

In the emotional social support satisfaction model, there were a number of significant findings. First, although emotional support satisfaction was not significantly related to mammography pain directly, the results suggested that lower emotional

support satisfaction significantly related to higher mammography pain catastrophizing ($p \leq 0.001$). Second, the results showed that higher mammography pain catastrophizing significantly related to higher mammography pain directly ($p \leq 0.001$). Third, because of the significant path between mammography pain catastrophizing and mammography pain, the indirect effect of emotional support satisfaction was evaluated. The Sobel test for emotional support satisfaction's indirect effect suggested that lower emotional support satisfaction was significantly related to higher mammography pain through pain catastrophizing ($Z = -2.73, p \leq 0.05$). Moderated mediation analyses revealed that the indirect effects of emotional support satisfaction were significantly different at varying levels of emotional support satisfaction ($p \leq 0.01$). Specifically, the mediation effects of pain catastrophizing on mammography pain were more pronounced at higher levels of emotional support satisfaction than for lower emotional support satisfaction. The results are presented in Figure 8.

3.4.2.2 Guidance Support Satisfaction

With regard to guidance social support satisfaction model, a number of findings were also significant. First, although guidance support satisfaction was not significantly related to mammography pain directly, the results suggested that lower guidance support satisfaction significantly related to higher mammography pain catastrophizing ($p \leq 0.05$). Second, the results showed that higher mammography pain catastrophizing significantly related to higher mammography pain directly ($p \leq 0.001$). Third, because

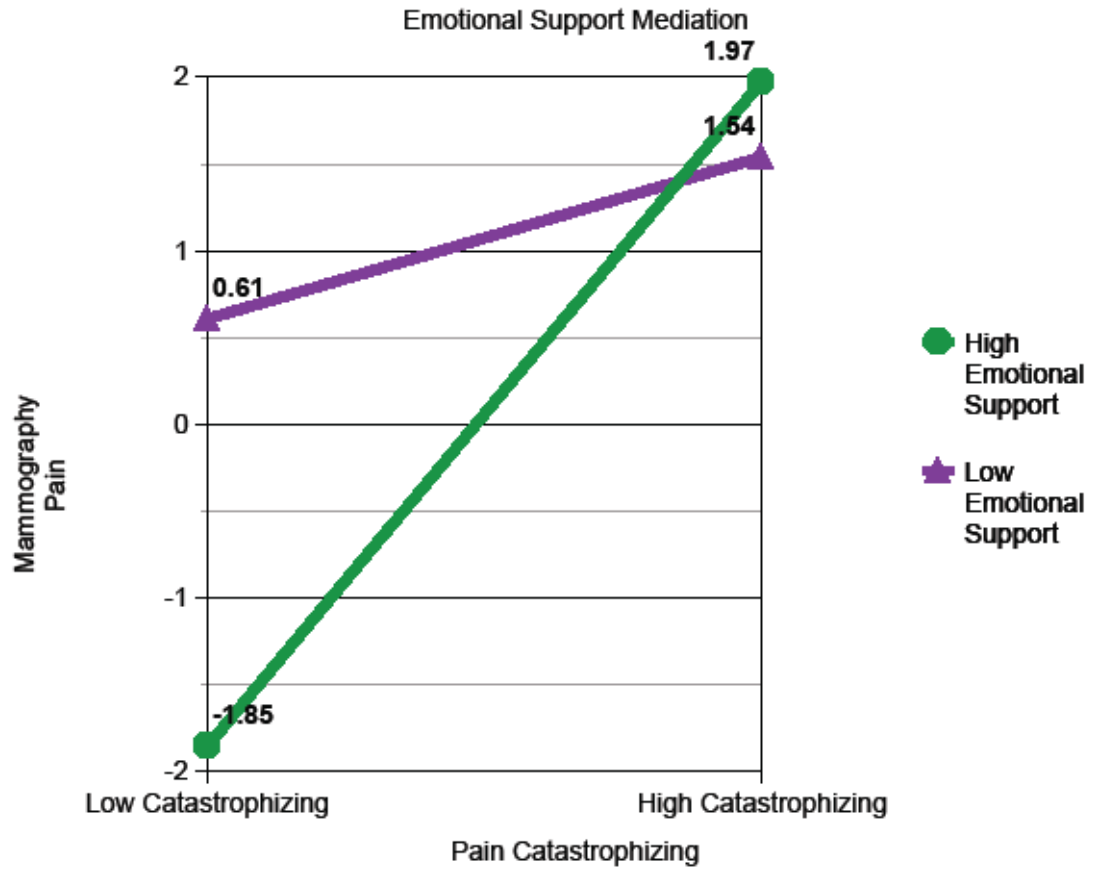


Figure 8: Emotional Support Satisfaction Mediation

of the significant path between mammography pain catastrophizing and mammography pain, the indirect effect of guidance support satisfaction was also evaluated. The Sobel test for guidance support satisfaction’s indirect effect suggested that lower guidance support satisfaction was significantly related to higher mammography pain through pain catastrophizing ($Z = -2.33, p \leq 0.05$). Moderated mediation analyses revealed that the indirect effects of guidance support satisfaction were significantly different at varying levels of guidance support satisfaction ($p \leq 0.01$). Specifically, the mediation

effects of pain catastrophizing on mammography pain were more pronounced at higher levels of guidance support satisfaction than for lower guidance support satisfaction. The results are presented in Figure 9.

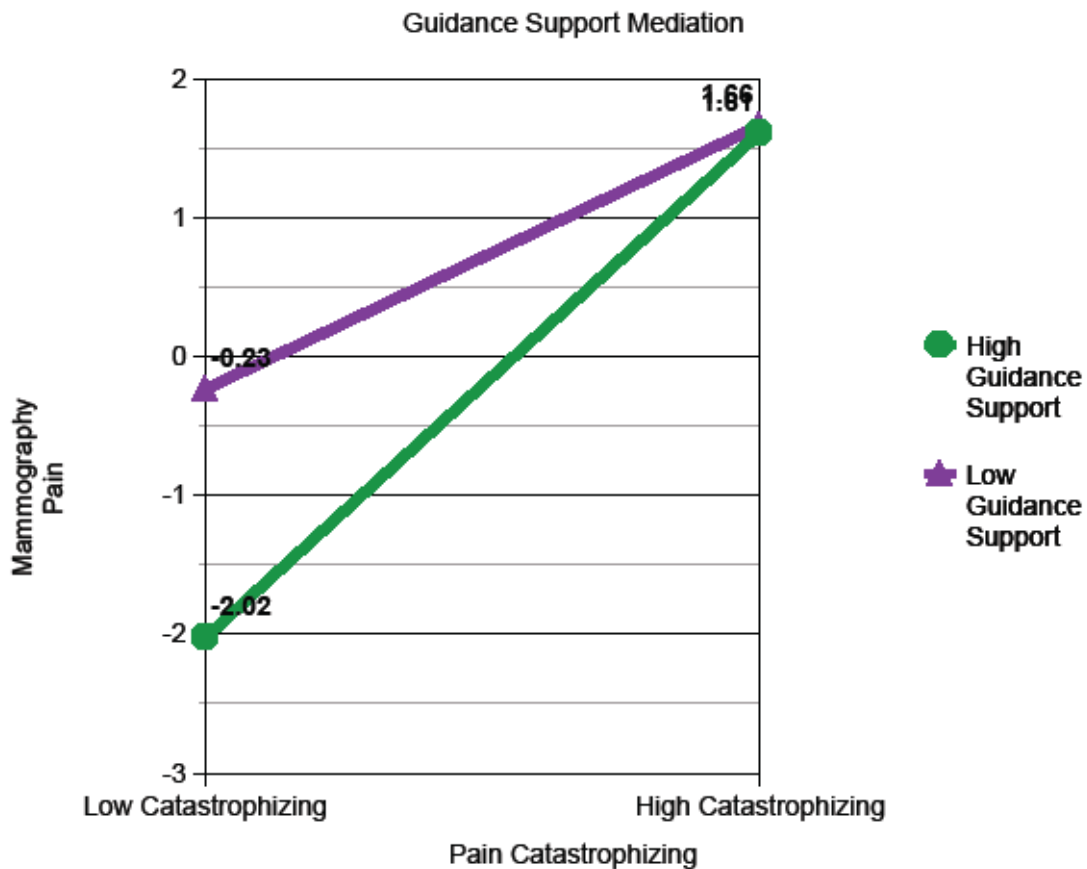


Figure 9: Guidance Support Satisfaction Mediation

4. Discussion

This discussion consists of three sections. First, the study findings are summarized, and theoretical, research and clinical research implications are presented.

Second, the strengths of the study are presented. Finally, study limitations are presented.

4.1 Summary of Findings

The overall objective of this study was to investigate the utility of a biopsychosocial model of mammography pain in breast cancer survivors. In order to meet this objective, three key issues were addressed.

The first issue was to determine which biological, psychological, and social challenges of breast cancer survivorship may be related to mammography pain individually. Within the current study, ongoing breast pain was the only biological factor to be tested. To my knowledge, this is the first investigation to explore the relationship between ongoing breast pain and mammography pain in breast cancer survivors. Bivariate results revealed that higher ongoing breast pain was significantly associated with high mammography pain. These results suggest that investigators should develop a theoretical framework within which to further explore ongoing breast pain as a correlate of mammography pain. These results are particularly meaningful given the number of breast cancer survivors who experience ongoing breast pain. It has been estimated that 20-57% of breast cancer survivors experience ongoing breast pain due to receiving cancer treatment, including surgery, radiation, and chemotherapy (Bishop & Warr, 2003; Given et al., 2001; Stevens et al., 1995; Uzun et al., 2004).

With regard to a theoretical framework for studying ongoing breast pain and mammography pain, future researchers could investigate the utility of the central sensitization model. Central sensitization theory as applied to chronic pain posits that when the central nervous system becomes sensitized to stimuli, this increased sensitivity results in reduced pain tolerance in acute situations (Dodick & Silberstein, 2006). Central sensitization theory has been applied to, and investigated within, a number of chronic pain syndromes including fibromyalgia (Price, Staud, Robinson, Mauderli, Cannon & Vierck, 2002; Staud, Cannon, Mauderli, Robinson, Price, & Vierck, 2003), headache (Buchgreitz, Lyngberg, Bendtsen, & Jensen, 2006; Dodick & Silberstein, 2006; Marcus, 2003), and neuropathic pain (Attal & Bouhassira, 1999; Koltzenburg, Torebjork, & Wahren, 1994). Within empirical investigations of central sensitization theory, researchers have found that those individuals suffering from a chronic pain condition report lower pain tolerance than healthy participants (Price et al., 2002; Staud et al., 2003). To my knowledge only one previous study, conducted by Gottrup et al (2000), has applied central sensitization theory to ongoing breast pain in breast cancer survivors. This study, however only included breast cancer survivors who had sensory disturbances in the surgical area, and was not conducted at the time of mammography. Future researchers could further explore the utility of a central sensitization model of mammography pain by examining the mammography pain experiences of breast cancer

survivors as compared to mammography experiences of healthy women with no cancer treatment history.

These results also suggest that clinicians interested in better understanding mammography pain should consider assessing ongoing breast pain as a potentially meaningful factor. One such study could explore the frequency and intensity of ongoing breast pain in the period surrounding mammography. For example, researchers could ask women to track ongoing breast pain daily in the weeks before a mammogram. This methodology could provide information on various aspects of how survivors experience ongoing breast pain, including the frequency, intensity, unpleasantness, and location(s) of their pain. Daily tracking would also allow for the pattern of ongoing breast pain to be examined. Specifically, researchers would be able to track if women experience increasing, stable, and/or decreasing pain for any appreciable periods of time prior to their mammogram. Additionally, this methodology could help researchers to determine if different cancer treatments are associated with varied ongoing breast pain experiences that might predispose them to more pain during mammography. For example, women who have surgery alone may experience more localized breast pain than women who undergo radiation or chemotherapy and thus be more likely to experience increased pain during mammography. Finally, this methodology could provide information on how different frequencies, intensities, and patterns of increasing/decreasing ongoing breast pain may be associated with mammography pain.

For example, a survivor of breast cancer who has been having frequent pain flares may experience more mammography pain than a woman who has infrequent pain flares. In addition, a woman who shows a pattern of increasing breast pain over several months might have a different mammography experience than a woman whose pattern of ongoing breast pain is stable or decreasing.

Regarding psychological factors, mammography-related pain catastrophizing and mammography-related anxiety were included in bivariate analyses to determine if they were correlated with mammography pain. These analyses revealed that both higher mammography-related pain catastrophizing and higher mammography-related anxiety were associated with higher mammography pain. These findings are important for a few key reasons. First, the current study's results support theoretical hypotheses and the vast empirical research suggesting that pain catastrophizing may be an important factor in the pain experience (for review, see Leeuw, Goossens, Linton, Crombez, Boersma, & Vlaeyen, 2007; Sullivan, Thorn, Haythornthwaite, Keefe, Martin, Bradley et al., 2001). However, only one previous study of pain catastrophizing and mammography pain found a statistically significant correlation (Ashghari & Nicholas, 2004), and this previous study was conducted with healthy women. As such, future studies should be conducted in order to replicate the current study's findings with breast cancer survivors. It might be particularly helpful for future investigations to test theoretical models for how pain catastrophizing may affect mammography pain.

The communal coping model of pain catastrophizing is one approach that can be applied to and tested with breast cancer survivors at mammography. In this model, posited by Sullivan, Tripp, & Santor (2000) and Keefe, Lefebvre, Egert, Affleck, Sullivan, & Caldwell (2000), pain catastrophizing is conceptualized as part of an interpersonal/communal style, and pain catastrophizing serves a social communicative role. This social communicative role could include soliciting social support, assistance, or empathic reactions from others. Severeijns, Vlaeyen, and van den Hout (2004) state that an underlying tenet of this model is, in pain catastrophizers, coping with pain in an interpersonal context may be more important than pain reduction. The communal coping model of pain has been investigated with healthy volunteers (Sullivan, Adams, & Sullivan, 2004; Sullivan, Martel, Tripp, Savard & Crombez, 2007) and with patients with chronic pain (Buenaver, Edwards & Haythornthwaite, 2007) and irritable bowel syndrome (Lackner & Gurtman, 2004). There is evidence that high catastrophizers may engage in pain coping strategies that more effectively communicate pain (e.g. displaying pain behaviors), but are less likely to engage in pain reducing strategies (e.g. distraction; Sullivan et al., 2004). To date, no studies have applied a communal coping model of pain catastrophizing to the mammography pain experience. Future research could do so by assessing 1) a breast cancer survivor's use of pain catastrophizing at the time of mammography, and 2) the survivor's perceptions of others' responses to her mammography pain. It can be hypothesized that if a survivor who is a pain

catastrophizier perceives the medical staff or her significant other as being particularly empathic, she may engage in more pain catastrophizing.

Future investigations of pain catastrophizing and mammography can also examine the utility of using a vigilance model of pain catastrophizing. Chapman (1978) posited that some individuals with chronic pain may engage in hypervigilance, constantly scanning the body for somatic sensations. More recently, investigators have examined how pain vigilance may be associated with maladaptive pain coping strategies and pain catastrophizing specifically. Goubert, Crombez, and Van Damme (2004) and Roelofs, Peters, McCracken, Vlaeyen (2003) have found that higher vigilance about pain is significantly related to higher pain catastrophizing in individuals with chronic pain. Researchers have also used fMRI to examine the relationship between brain activity in regions associated with vigilance/attention and pain catastrophizing (Gracely, Geisser, Giesecke, Grant, Petske, & Williams, 2004; Seminowicz & Davis, 2006). To date, however, there have been no studies of breast cancer survivors that have examined the relationship between pain vigilance and pain catastrophizing in the context of mammography. Future researchers could do so by having women complete measures of pain vigilance, pain catastrophizing, and mammography pain immediately following the mammogram. Such research could use the Pain Vigilance and Awareness Questionnaire (PVAQ; McCracken, 1997) to explore pain vigilance, a measure that has

been validated in chronic pain patients and healthy volunteers (McCracken, 1997; Roelofs et al., 2004).

The current study's results regarding mammography-related anxiety are novel, in that this was the first investigation to explore the association between mammography-related anxiety and mammography pain. Mammography-related anxiety was operationalized as hyperarousal, intrusive thoughts, dissociation, and avoidance about the upcoming mammogram. The current findings suggest that survivors who experience more mammography-related anxiety may experience more mammography pain. These findings support findings in breast cancer samples that suggest anticipatory anxiety is associated with increased post-operative pain (Katz et al., 2005; Montgomery & Bovberg, 2004). Taken together, these studies suggest that additional research is warranted to further explore the potential relationship between mammography-related anxiety and mammography pain. In the current study, breast cancer survivors were asked to rate the previous week's mammography-related anxiety. Future studies could replicate this method or could evaluate mammography-related anxiety at various time-points preceding the mammogram. One such approach would be to recruit survivors of breast cancer in the weeks before a mammogram and obtain weekly assessments of anxiety. Another approach would be to conduct daily anxiety and mood ratings throughout the week immediately before a mammogram.

Researchers also could examine anxiety immediately following a mammogram, before survivors are notified of the mammography results.

With regard to social factors, this study is the first to assess the relationships between social support quality and quantity and mammography pain. Bivariate results revealed that lower perceived quality of social support, including greater mismatches in support, lower emotional support satisfaction, and lower guidance support satisfaction, were all significantly associated with higher mammography pain. Social support quantity was not significantly associated with mammography pain. These findings are important for a few reasons. First, perceived quality of social support has been hypothesized to be a particularly meaningful factor in breast cancer survivorship (Beder, 1995; Ferrell et al., 1997; Green et al., 2000; Levy et al., 1990; Sammarco, 2001). More specifically, previous researchers have provided empirical data suggesting that for breast cancer survivors, higher perceived social support is significantly associated with less fatigue (Ferrell, et al., 1997), less depressive and anxiety symptoms (Green et al., 2000), and less negative affect (Budin, 1998). Additionally, breast cancer survivors with higher perceived quality of social support have also reported higher quality of life (Beder, 1995; Sammarco, 2001, 2003) than survivors with lower perceived quality of social support. Moreover, a larger mismatch between a breast cancer survivor's desired social support and her received social support has been associated with worse psychosocial adjustment to breast cancer (Reynolds & Perrin, 2004). Taken together,

these previous investigations, along with the current study's findings suggest that future researchers should continue to develop theoretical models within which to explore how perceived quality of social support may relate to mammography pain.

There are a few established theoretical models for social support and pain that could be applied to future research on the mammography pain experiences of breast cancer survivors. First the stress-buffering hypothesis posited by Cohen & Willis (1985) could be further explored. Cohen & Willis (1985) posited that social support becomes particularly salient during a stressful event, and can buffer against stress-related negative outcomes. To test this hypothesis, researchers could assess the relative importance of social support on the pain experience in breast cancer survivors in a variety of situations, including standard experimental pain protocols and the (presumably) more stressful mammography pain experience. Another theoretical approach that could be further explored is that of Reynolds & Perrin (2004), who posited that mismatches in social support are associated with poorer psychosocial adjustment in breast cancer survivors. Future investigators could test this hypothesis by first assessing social support preferences. They could then randomly assign survivors to receive a specific type of support during mammography, that either matches their support preference or not.

In addition to these biological and psychosocial factors being significantly related to mammography pain, bivariate results also revealed that many of the factors were significantly related to each other. Higher ongoing breast pain was significantly related

to higher mammography-related pain catastrophizing and higher mammography-related anxiety. Higher mammography-related pain catastrophizing was significantly related to higher mammography-related anxiety, lower perceived quality of social support and higher social support quantity. Higher mammography-related anxiety was significantly related to lower perceived quality of social support, and higher quantity social support. These significant intercorrelations are important because they emphasize the simultaneous challenges that many breast cancer survivors face.

The second issue the current study addressed was how these biological, psychological, and social factors may simultaneously affect the mammography experience. Initial path analyses revealed that mammography-related pain catastrophizing and mammography-related anxiety in particular were highly correlated. In order to reduce Type II error and create a model that better fit the data, the choice was made to trim the path analysis to include either mammography-related pain catastrophizing or mammography-related anxiety. Mammography-related anxiety was excluded for a few important reasons. First, and most importantly, mammography-related anxiety was not significantly related to mammography pain in path analyses when other factors were considered simultaneously. Pain catastrophizing remained significantly related to mammography pain in path analyses. Second, in order to assess indirect associations to mammography pain, it was important that mammography-related anxiety or mammography-related pain catastrophizing be significantly related to

other variables in the model. Mammography-related pain catastrophizing was significantly related to more variables than was mammography-related anxiety. All subsequent analyses were then conducted with this trimmed path model. Subsequent path analysis revealed that when relevant factors were explored simultaneously, mammography-related pain catastrophizing remained the only factor that was significantly related to mammography pain directly.

The novel aspect of the study's results is it is the first to provide support for mammography-related pain catastrophizing as potentially being one of the most important factors affecting the mammography pain experience of breast cancer survivors. These findings are interesting and suggest that one might consider incorporating assessments of mammography-related pain catastrophizing into the standard mammography protocol for breast cancer survivors. Regarding assessment, the current study used a methodology for gathering this data in a practical manner: immediately following the mammogram. This methodology utilized a waiting period that was already part of a survivor's standard mammography experience. This structure is feasible for clinicians and researchers since it allows one to readily identify women who may have difficulty coping with the pain of future mammograms.

In addition to assessment, psychological interventions to target mammography-related pain catastrophizing could also be designed to coincide with an upcoming mammogram. Previous investigators have suggested that traditional pain coping skills

training (e.g. progressive muscle relaxation, distraction, diaphragmatic breathing) may not be as effective for individuals who are high pain catastrophizers (Geisser, Robinson, & Riley, 1999; Sullivan et al., 2001; Thorn, Pence, Ward, Kilgo, Clements, Cross, et al., 2007). Instead, it has been hypothesized that individuals who are high on pain catastrophizing may benefit from receiving psychological interventions that incorporate more cognitive restructuring than traditional pain coping programs. Thorn and colleagues (2007) proposed a 5-session cognitive restructuring protocol specifically aimed at reducing pain catastrophizing in chronic pain populations. This protocol structure consisted of:

Session 1- Introduce the stress-pain connection and the cognitive model for pain.

Session 2- Define and identify automatic thoughts; Identify emotional, behavioral, and physical changes associated with negative thinking.

Session 3- Examine automatic thoughts; Develop alternative, more adaptive thoughts; Identify emotional, behavioral, and physical changes resulting from alternative thinking.

Session 4- Define and identify negative intermediate and core beliefs; Introduce techniques used to modify maladaptive beliefs.

Session 5- Introduce coping cards as a method for modifying frequent negative automatic thoughts; Construct and use positive self-statements.

One advantage of this type of protocol is that its in-depth cognitive approach targets maladaptive cognitions throughout a number of sessions. However, if a survivor does not experience such cognitions, this type of treatment may not be appropriate or helpful. Additionally, a 5-session protocol may not be practical at the time of mammography. These drawbacks could be addressed by first assessing for the presence of maladaptive pain cognitions. If present, a 1-session intervention, specifically tailored for addressing catastrophizing in the context of mammography, could be provided. Such an intervention could focus on: identifying automatic thoughts about mammography pain, developing more adaptive thoughts, and constructing and using positive self-statements. This brief intervention could be conducted within the standard waiting period immediately before a mammogram. An alternative strategy would be to conduct a 2-3 session intervention in the weeks before a mammogram. This approach has the added benefit of allowing women more of an opportunity to practice the cognitive restructuring skills they learn.

While path analyses supported a direct relationship between mammography-related pain catastrophizing and mammography pain, no other direct associations with mammography pain remained significant. One reason that this may have occurred is that some factors may have had significant indirect associations with mammography pain, with mammography-related pain catastrophizing functioning as a mediator of these relationships. Sobel tests of indirect effects and moderated mediation analyses

were conducted in order to further explore this hypothesis. With regard to ongoing breast pain, these results revealed that ongoing breast pain was associated with mammography pain indirectly, with mammography-related pain catastrophizing significantly mediating this relationship. Results also revealed that this mediation relationship was consistent across varying levels of ongoing breast pain. Taken together, these findings suggest that pain catastrophizing may be the mechanism by which a person's breast pain history affects the mammography experience.

Regarding social support, Sobel tests of indirect effects revealed that perceived quality of social support was associated with mammography pain indirectly, with mammography-related pain catastrophizing significantly mediating this relationship. Analyses also revealed that the mediating effects of mammography-related pain catastrophizing were significantly different at varying levels of perceived quality of support. Specifically, mammography-related pain catastrophizing had a stronger negative impact on mammography pain for women who reported high perceived quality support than it did for those with low quality support. These results seem to suggest that mammography-related pain catastrophizing may dampen the protective/buffering effects of social support that were hypothesized by Cohen and Willis (1985). These results may be explained by the communal coping model of pain catastrophizing (Sullivan et al., 2000; Keefe et al., 2000). As stated earlier, this model posits that pain catastrophizing may serve a social communicative role. For women who perceive

themselves as having higher quality social support, their use of pain catastrophizing may be helpful in garnering assistance or generating empathic responses from others. However, their use of pain catastrophizing may also be negatively affecting their mammography experience.

4.2 Study Strengths

The most notable strength of the current investigation is that it was the first to investigate the direct indirect associations between ongoing breast pain, mammography-related pain catastrophizing, mammography-related anxiety, social support, and mammography pain in breast cancer survivors. While some of these factors have been previously evaluated for their individual correlations with mammography pain, the novel biopsychosocial model presented in this study provides the framework by which one can continue studying mammography in a more comprehensive manner. This comprehensive approach may be particularly salient for breast cancer survivors, as they have been found to experience a multitude of biological and psychosocial challenges beyond those that were assessed in the current investigation. More specifically, previous research has found that following treatment, survivors of breast cancer may experience persisting fatigue (Beisecker et al., 1997; Lindley, Vasa, Sawyer, & Winer, 1998; Stone et al., 2003), sleep disturbance (Degner & Sloan, 1995; Fortner, Stepanski,

Wang, Kasprowicz, & Durrence, 2002; Savard, Simard, Blanchet, Ivers, & Morin, 2001), and negative affect (Gurevich et al., 2004; Jacobsen et al.,

1993). Future studies of mammography pain could apply the current study's biopsychosocial model to assess how these additional challenges may directly and indirectly relate to the mammography pain experience.

This study also had a number of methodological strengths. For one, it was conducted during mammography, a salient aspect of the breast cancer survivorship experience. As women continue to live longer following a breast cancer diagnosis and treatment, survivorship experiences may become an increasingly important factor in morbidity and mortality trends over time.

Another methodological strength was the non-invasive nature of data collection. Informed consent and measure administration were all performed during waiting periods that were already part of standard care at the mammography clinic. This strategy helped to minimize participant burden. Finally, this study was strengthened by the use of well-validated measures, with minor changes that tailored them specifically for mammography.

4.3 Study Limitations

There are also some important limitations that are worth noting. First, the study sample included mostly well-educated, married women of higher socioeconomic status.

These women represent breast cancer survivors with the most informational, social, and economic resources, and previous research suggests that these socioeconomic variables may be important to pain coping and the experience of pain (Cano, Mayo, Ventimiglia, 2006; Junghaenel, Schwartz, & Broderick, 2008). In order to determine the validity of the current study's findings, the results would need to be replicated in samples of breast cancer survivors with less economic and social resources. One strategy that may be helpful in this area could be to recruit participants through facilities and clinics that provide healthcare for women with Medicaid and Medicare. Additionally, future researchers could recruit participants through programs that have been designed to provide free annual mammograms.

As the current study only assessed these biological and psychosocial factors in a cross-sectional design, it would be important in future investigations to explore causal relationships between these variables, in order to determine if biological and social factors cause maladaptive coping or vice versa. For example, one could imagine a scenario in which a woman with little/no pain history then experiences ongoing breast pain following cancer treatment, she may engage in maladaptive pain coping strategies like pain catastrophizing. Future investigations that establish these temporal relationships could be instrumental for determining which factor(s) should be the primary focus of intervention. To establish these temporal relationships, investigators could assess these factors using well-established daily data collection methodology at

salient time-points throughout treatment and survivorship, including 1) before the initiation of cancer treatment (i.e. surgery, chemotherapy, radiation therapy), 2) during the acute recovery period following treatment, 3) 6 months following treatment, and 4) at the time of annual mammography. These daily data collection methods have been utilized effectively with cancer patient samples (Rumble, Keefe, Edinger, Porter, & Garst, 2005; Sherliker & Steptoe, 2000; Wu & McSweeney, 2007), and allow for statistical analyses that examine how one day's ratings of challenges may affect subsequent days' ratings. This method would also allow for researchers to examine how biopsychosocial challenges predict initial and subsequent pain experiences during mammography. We are currently conducting such a longitudinal study to assess how challenges at the time of survivors' first mammogram relate to: 1) subsequent mammography pain and 2) rates of return for annual mammograms.

References

- American Cancer Society (n.d.). *Overview: Breast Cancer*. Retrieved September 14, 2008, from http://www.cancer.org/docroot/CRI/CRI_2_1x.asp?dt=5
- Andrews, F. J. (2001). Pain during mammography: Implications for breast screening programmes. *Australasian Radiology, 45*(2), 113-117.
- Armer, J. & Fu, M. R. (2005). Age differences in post-breast cancer lymphedema signs and symptoms. *Cancer Nursing, 28*(3), 200-207.
- Asghari, A. & Nicholas, M. K. (2004). Pain during mammography: The role of coping strategies. *Pain, 108* (1-2), 170-179.
- Attal, N. & Bouhassira, D. (1999). Mechanisms of pain in peripheral neuropathy. *Acta Neurologica Scandinavica Supplementum, 100* (Suppl 173), 12-24.
- Barrera, M.J. & Ainlay, S. L. (1983). The structure of social support: A conceptual and empirical analysis. *Journal of Community Psychology, 11*, 133-143.
- Barrera, M., Sandler, IN., & Ramsay, RB (1981). Preliminary development of a scale of social support: Studies on college students. *American Journal of Community Psychology, 9*, 435-447.
- Barsky, A. J., Wyshak, G., & Klerman, G. (1990). The somatosensory amplification scale and its relationship to hypochondriasis. *Journal of Psychiatric Research, 24*, 323-334.
- Beck, A. T., Ward, C. H., Mendelson, M., Mock, J., & Erbaugh, J. (1961). An inventory for measuring depression. *Archives of General Psychiatry, 4*, 561-571.
- Beder J. (1995). Perceived social support and adjustment to mastectomy in socioeconomically disadvantaged black women. *Social Work in Health Care. 22*(2), 55-71.
- Beisecker, A., Cook, M. R., Ashworth, J., Hayes, J., Brecheisen, M., Helmig, L. et al. (1997). Side effects of adjuvant chemotherapy: Perceptions of node-negative breast cancer patients. *Psycho-Oncology, 6*(2), 85-93.

- Bishop, S. R. & Warr, D. (2003). Coping, catastrophizing and chronic pain in breast cancer. *Journal of Behavioral Medicine, 26*(3), 265-281.
- Brady, M. J., Cella, D. F., Mo, F., Bonomi, A.E., Tulsky, D. S., Lloyd, S. R., et al. (1997). Reliability and validity of the functional assessment of cancer therapy- Breast quality of life instrument. *Journal of Clinical Oncology, 15*, 974-986
- Broadhead, W. E., Elbach, S. H., de Gruy, F. V., & Kaplan, B. J. (1988). The Duke-UNC Functional Social Support Questionnaire: Measurement of social support in family medicine patients. *Medical Care, 26*, 709-723.
- Brown, J. L., Sheffield, D., Leary, M. R., & Robinson, M. E. (2003). Social support and experimental pain. *Psychosomatic Medicine, 65*(2), 276-283.
- Buchgreitz, L., Lyngberg, A., Bendtsen, L., & Jensen, R. (2006). Frequency of headache is related to sensitization: A population study. *Pain, 123* (1-2), 19-27.
- Budin, W. C. (1998). Psychosocial adjustment to breast cancer in unmarried women. *Research in Nursing & Health, 21*(2), 155-166.
- Byrne, B. M. (2001). *Structural equation modeling with AMOS: Basic concepts, applications, and programming*. New Jersey: Lawrence Erlbaum Associates.
- Campbell, L. C., Keefe, F. J., Scipio, C., McKee, D. C., Edwards, C. L., Herman, S. H. et al. (2007). Facilitating research participation and improving quality of life for African American prostate cancer survivors and their intimate partners. A pilot study of telephone-based coping skills training. *Cancer, 109*(2 Suppl), 414-424.
- Cano, A., Mayo, A., & Ventimiglia, M (2006). Coping, pain severity, interference, and disability: The potential mediating and moderating roles of race and education. *The Journal of Pain, 7*(7), 459-468.
- Cardena, E., Koopman, C., Classen, C., Waelde, L. C., & Spiegel, D. (2000). Psychometric properties of the Stanford Acute Stress Reaction Questionnaire (SASRQ): A valid and reliable measure of acute stress. *Journal of Traumatic Stress, 13*(4), 719-734.
- Carson, J. W., Keefe, F. J., Affleck, G., Rumble, M. E., Caldwell, D. S., Beaupre, P. M., et al. (2006). A comparison of conventional pain coping skills training and pain coping skills training with a maintenance training component: a daily diary analysis of short- and long-term treatment effects. *Journal of Pain, 7*(9), 615-625.

- Cella, D. F., Tulsky, D. S., Gray, G., Sarafian, B., Linn, E., Bonomi, A. et al. (1993). The functional assessment of cancer therapy scale: Development and evaluation of the general measure. *Journal of Clinical Oncology*, 11, 570-579.
- Cheung, Y. L., Molassiotis, A., & Chang, A. M. (2003). The effect of progressive muscle relaxation training on anxiety and quality of life after stoma surgery in colorectal cancer patients. *Psycho-Oncology*, 12(3), 254-266.
- Clauw, D. J., Williams, D., Lauerman, W., Dalman, M., Aslami, A., Nachemson, A. L., et al. (1999). Pain sensitivity as a correlate of clinical status in individuals with chronic low back pain. *Spine*, 24(19), 2035-2041.
- Cleeland, C. S. (1989). Measurement of pain by subjective report. In: C. R. Chapman and J. D., Loeser (Eds.), *Issues in Pain Management*. New York: Raven.
- Cohen S, Mermelstein R, Kamarck T, Hoberman H. (1985). Measuring the functional components of social support. In: I. Sarason & B. R. Sarason (Eds.) *Social Support: Theory, Research, and Applications*. The Hague, Holland: Martinus Nijhoff; 73-94.
- Cohen, S. & Willis, T. (1985). Stress, social support, and the buffering hypothesis. *Psychological Bulletin*, 98 (2), 310-357.
- Con, A. H., Linden, W., Thompson, J. M., & Ignaszewski, A. (1999). The psychology of men and women recovering from coronary artery bypass surgery. *Journal of Cardiopulmonary Rehabilitation*, 19(3), 152-161.
- Degner, L. F. & Sloan, J. A. (1995). Symptom distress in newly diagnosed ambulatory cancer patients and as a predictor of survival in lung cancer. *Journal of Pain and Symptom Management*, 10(6), 423-431.
- Dijkstra, P. U., Rietman J. S., & Geertzen, J. H. (2007). Phantom breast sensations and phantom breast pain: A 2-year prospective study and a methodological analysis of literature. *European Journal of Pain*, 11(1), 99-108.
- Dodick, D. & Silberstein, S. (2006). Central sensitization theory of migraine: Clinical implications. *Headache: The Journal of Head and Face Pain*, 46 (Suppl 4), S182-S191.
- Edwards, R. R., Smith, M. T., Stonerock, G., & Haythornthwaite, J. A. (2006). Pain-related catastrophizing in healthy women is associated with greater temporal

summation of and reduced habituation to thermal pain. *Clinical Journal of Pain*, 22(8), 730-737.

Elwood, M., McNoe, B., Smith, T., Bandaranoyake, M., & Doyle, T. C. (1998). Once is enough- Why some women do not continue to participate in a breast cancer screening programme. *New Zealand Medical Journal*, 111(1066), 180-183.

Emery, C. F., Keefe, F. J., France, C. R., Affleck, G., Waters, S., Fondow, M. D. et al. (2006). Effects of a brief coping skills training intervention on nociceptive flexion reflex threshold in patients having osteoarthritic knee pain: a preliminary laboratory study of sex differences. *Journal of Pain & Symptom Management*, 31(3), 262-269.

Ferrell, B. R., Grant, M., Funk, B., Otis-Green, S., Garcia, N. (1998). Quality of life in breast cancer survivors: Implications for developing support services. *Oncology Nursing Forum*, 25(5), 887-895.

Flaherty, J. A., Gavaria, FM, Pathak, DS. (1993). The measurement of social support: The social support network inventory. *Comprehensive Psychiatry*, 24, 521-529.

Fortner, B. V., Stepanski, E. J., Wang, S. C., Kasprovicz, S., & Durrence, H. H. (2002). Sleep and quality of life in breast cancer patients. *Journal of Pain and Symptom Management*, 24(5), 471-480.

Ganel, A., Engel, J., Sela, M., & Brooks, M. (1979). Nerve entrapments associated with postmastectomy lymphedema. *Cancer*, 44(6), 2254-2259.

Geisser, M. E., Gracely, R. H., Giesecke, T., Petske, F. W., Williams, D. A., & Clauw, D. J. (2007). The association between experimental and clinical pain measures among persons with fibromyalgia and chronic fatigue syndrome. *European Journal of Pain*, 11(2), 202-207.

Geisser, M., Robinson, M., & Riley, J. (1999). Pain beliefs, coping, & adjustment to chronic pain: Let's focus more on the negative. *Pain Forum*, 8, 161-168.

Gracely, R., Geisser, M., Giesecke, T., Grant, M., Petzke, F., Williams, D., & Clauw, D. (2004). Pain catastrophizing and neural responses to pain among persons with fibromyalgia. *Brain: A Journal of Neurology*, 127 (4), 835-843.

Green, B. L., Krupnick, J. L., Rowland, J. H., Epstein, S. A., Stockton, P., Spertus, I. et al.

- (2000). Trauma history as a predictor of psychologic symptoms in women with breast cancer. *Journal of Clinical Oncology*, 18(5), 1084-1093.
- Gil, K. M., Carson, J. W., Sedway, J. A., Porter, L. S., Schaeffer, J. J. & Orringer, E. (2000). Follow-up of coping skills training in adults with sickle cell disease: Analysis of daily pain and coping practice diaries. *Health Psychology*, 19(1), 85-90.
- Given, C. W., Given, B., Azzouz, F., Kozachik, S., & Stommel, M. (2001). Predictors of pain and fatigue in the year following diagnosis among elderly cancer patients. *Journal of Pain & Symptom Management*, 21(6), 456-466.
- Gottrup, H., Andersen, J., Arendt-Nielsen, L., & Jensen, T. S. (2000). Psychophysical examination in patients with post-mastectomy pain. *Pain*, 87, 275-284.
- Gottrup, H., Kristensen, A. D., Bach, F. W., & Jensen, T. S. (2003). Aftersensations in experimental and clinical hypersensitivity. *Pain*, 103(1-2), 57-64.
- Goubert, L., Crombez, G., & Van Damme, S. (2004). The role of neuroticism, pain catastrophizing and pain-related fear in vigilance to pain: A structural equations approach. *Pain*, 107 (3), 234-241.
- Granot, M. & Ferber, S. G. (2005). The roles of pain catastrophizing and anxiety in the prediction of postoperative pain intensity: A prospective study. *Clinical Journal of Pain*, 21(5), 439-445.
- Green, B. L., Krupnick, J. L., Rowland, J. H., Epstein, S. A., Stockton, P., Spertus, I. et al. (2000). Trauma history as a predictor of psychologic symptoms in women with breast cancer. *Journal of Clinical Oncology*, 18(5), 1084-1093.
- Gurevich, M., Devins, G. M., Wilson, C., McCready, D., Marmar, D. C. R., & Rodin, G. M. (2004). Stress response syndromes in women undergoing mammography: A comparison of women with and without a history of breast cancer. *Psychosomatic Medicine*, 66(1), 104-112.
- Hamilton, M. (1959). The assessment of anxiety states by rating. *British Journal of Medical Psychology*, 32, 50-55.
- Hamilton, M. (1960). A rating scale for depression. *Journal of Neurology, Neurosurgery, and Psychiatry*, 23, 56-61.
- Harris, R. E., Gracely, R. H., McLean, S. A., Williams, D. A., Giesecke, T., Petzke, F., et

- al. (2006). Comparison of clinical and evoked pain measures in fibromyalgia. *Journal of Pain*, 7(7), 521-527.
- Hilkens, P. H., Pronk, L. C., Verweij, J., Vecht, C. J., van Putten, W. L., van den Bent, M. J. (1997). Peripheral neuropathy induced by combination chemotherapy of docetaxel and cisplatin. *British Journal of Cancer*, 75(3), 417-422.
- Hodnett, E. D., Gates, S., Hofmeyr, G. J., & Sakala, C. (2003). Continuous support for women during childbirth. *Cochrane Database of Systematic Reviews*.
- Jacobsen, P. B., Bovbjerg, D. H., & Redd, W. H. (1993). Anticipatory anxiety in women receiving chemotherapy for breast cancer. *Health Psychology*, 12(6), 469-475.
- Junghaenel, D., Schwartz, J., & Broderick, J. (2008). Differential efficacy of written emotional disclosure for subgroups of fibromyalgia patients. *British Journal of Health Psychology*, 13(1), 57-60.
- Kashikar-Zuck, S., Keefe, F. J., Kornguth, P., Beaupre, P., Holzberg, A., & Delong, D. (1997). Pain coping and the pain experience during mammography: A preliminary study. *Pain*, 73(2), 165-172.
- Katz, J., Peloshuck, E. L., Andrus, C. H., Hogan, L. A., Jung, B. F., Kulick, D. I. et al. (2005). Risk factors for acute pain and its persistence following breast cancer surgery. *Pain*, 119(1-3), 16-25.
- Keefe, F. J., Blumenthal, J., Baucom, D., Affleck, G., Waugh, R., Caldwell, D. S., et al. (2004). Effects of spouse-assisted coping skills training and exercise training in patients with osteoarthritic knee pain: A randomized controlled study. *Pain*, 110(3), 539-549.
- Keefe, F., Lefebvre, J., Egert, J., Affleck, G., Sullivan, M., & Caldwell, D. (2000). The relationship of gender to pain, pain behaviors, and disability in osteoarthritis patients: The role of catastrophizing. *Pain*, 87 (3), 325-334.
- Keemers-Gels, M. E., Groenendijk, R. P., van den Heuvel, J. H., Boetes, C., Peer, P. G., & Wobbes, T. H. (2000). Pain experienced by women attending breast cancer screening. *Breast Cancer Research & Treatment*, 60(3), 235-240.
- Keller, S., Bann, C. M., Dodd, S. L., Schein, J., Mendoza, T. R., & Cleeland, C. S. (2004). Validity of the brief pain inventory for use in documenting the outcomes of

- patients with noncancer pain. *Clinical Journal of Pain*, 20(5), 309-318.
- Kelsen, D. P., Portenoy, R. K., Thaler, H. T., Niedzwiecki, D., Passik, S. D., Tao, Y. et al. (1995). Pain and depression in patients with newly diagnosed pancreas cancer. *Journal of Clinical Oncology*, 13(3), 748-755.
- Klepstad, P., Loge, J. H., Borchgrevink, P. C., Mendoza, T. R., Cleeland, C. S., & Kaasa, S. (2002). The Norwegian Brief Pain Inventory Questionnaire: Translation and validation in cancer pain patients. *Journal of Pain and Symptom Management*, 24(5), 517-525.
- Kline, R. B. (1998). *Principles and practice of structural equation modeling*. New York: Guilford Press.
- Koltzenburg, M., Torebjork, H., & Wahren, L. (1994). Nociceptor modulated central sensitization causes mechanical hyperalgesia in acute chemogenic and chronic neuropathic pain. *Brain: A Journal of Neurology*, 117 (3), 579-591.
- Kornguth, P. J., Keefe, F. J., Wright, K. R., & Delong, D. M. (2000). Mammography pain in women treated conservatively for breast cancer. *The Journal of Pain*, 1(4), 268-274.
- Kulik, J. & Mahler, H. I. (1989). Social support and recovery from surgery. *Health Psychology*, 8(2), 221-238.
- Lackner, J. & Gurtman, M. (2004). Pain catastrophizing and interpersonal problems: A circumplex analysis of the communal coping model. *Pain*, 110 (3), 597-604.
- Laursen, B. S., Bajaj, P., Olesen, A. S., Delmar, C., Arendt-Nielsen, L. (2005). Health related quality of life and quantitative pain measurement in females with chronic non-malignant pain. *European Journal of Pain*, 9(3), 267-275.
- Leeuw, M., Goossens, M. E., Linton, S. J., Crombez, G., Boersma, K., & Vlaeyen, J. W. (2007). The fear-avoidance model of musculoskeletal pain: Current state of scientific evidence. *Journal of Behavioral Medicine*, 30(1), 77-94.
- Levy, S. M., Herberman, R. B., Lee, J., Whiteside, T., Kirkwood, J., & McFeeley, S. (1990). Estrogen receptor concentration and social factors as predictors of natural killer cell activity in early-stage breast cancer patients: Confirmation of a model. *Natural Immunity & Cell Growth Regulation*, 9(5), 313-324.

- Levy, S. M., Herberman, R., Whiteside, T., Sanzo, K., Lee, J., & Kirkwood, J. (1990). Perceived social support and tumor estrogen/progesterone receptor status as predictors of natural killer cell activity in breast cancer patients. *Psychosomatic Medicine*, 52(1), 73-85.
- Lindley, C., Vasa, S., Sawyer, W., & Winer, E. (1998). Quality of life and preferences for treatment following systemic adjuvant therapy for early stage breast cancer. *Journal of Clinical Oncology*, 16(4), 1380-1387.
- Logan, D. E. & Rose, J. B. (2005). Is postoperative pain a self-fulfilling prophecy? Expectancy effects on postoperative pain and patient-controlled analgesia use among adolescent surgical patients. *Journal of Pediatric Psychology*, 30(2), 187-196.
- Loudon, L. & Petrek, J. (2000). Lymphedema in women treated for breast cancer. *Cancer Practice*, 8(2), 65-71.
- Marcus, D. (2003). Central sensitization: An important factor in the pathogenesis of chronic headache. *Headache Quarterly*, 14 (1), 19-23.
- McBride, C. M., Baucom, D. H., Peterson, B. L., Pollak, K. I., Palmer, C., Westman, E., et al. (2004). Prenatal and postpartum smoking abstinence a partner-assisted approach. *American Journal of Preventive Medicine*, 27(3), 232-238.
- McCracken, L. (1997). "Attention" to pain in persons with chronic pain: A behavioral approach. *Behavior Therapy*, 28(2), 271-284.
- Melzack, R. (1975). The McGill Pain Questionnaire: Major properties and scoring methods. *Pain*, 1(3), 277-299.
- Melzack, R. & Wall, P. D. (1965). Pain mechanisms: A new theory. *Science*, 150(3699), 971-979.
- Millar, K., Purushotham, A. D., McLatchie, E., George, W. D., & Murray, G. D. (2005). A 1-year, prospective study of individual variation in distress, and illness perceptions, after treatment for breast cancer. *Journal of Psychosomatic Research*, 58, 335-342.
- Mondrup, K., Olsen, N. K., Pfeiffer, P., & Rose, C. (1990). Clinical and electrodiagnostic findings in breast cancer patients with radiation-induced brachial plexus

neuropathy. *Acta Neurologica Scandinavica*, 81(2), 153-158.

- Montgomery, G. H. & Bovbjerg, D. H. (2004). Presurgery distress and specific response expectancies predict postsurgery outcomes in surgery patients confronting breast cancer. *Health Psychology*, 23(4), 381-387.
- Northouse, L. L., Caffey, M., Deichelbohrer, L., Schmidt, L., Guziattek-Trojniak, L., West, S., et al. (1999). The quality of life of African-American women with breast cancer. *Research in Nursing & Health*, 22(6), 449-460.
- Osman, A., Barrios, F. X., Gutierrez, P. M., Kopper, B. A., Merrifield, T., & Grittmann, L. (2000). The Pain Catastrophizing Scale: Further psychometric evaluation with adult samples. *Journal of Behavioral Medicine*, 23(4), 351-365.
- Papas, M. A. & Klassen, A. C. (2005). Pain and discomfort associated with mammography among urban low-income African-American women. *Journal of Community Health*, 30(4), 253-267.
- Pavlin, D. J., Sullivan, M. J., Freund, P. R., & Roesen, K. (2005). Catastrophizing: A risk factor for postsurgical pain. *Clinical Journal of Pain*, 21(1), 83-90.
- Pawlow, L. A. & Jones, G. E. (2005). The impact of abbreviated progressive muscle relaxation on salivary cortisol and salivary immunoglobulin a (sIgA). *Applied Psychophysiology and Biofeedback*, 30(4), 375-387.
- Pearson, J. (1986). The definition and measurement of social support. *Journal of Counseling and Development*, 64, 390-395.
- Pilowsky, I. & Spence, N. D. (1975). Patterns of illness behavior in patients with intractable pain. *Journal of Psychosomatic Research*, 19, 279-287.
- Pilowsky, I. & Spence, N. D. (1994). *Manual for the illness behavior questionnaire. 2nd edition*. Adelaide, Australia: University of Adelaide.
- Price, D., Staud, R., Robinson, M., Mauderli, A., Cannon, R., & Vierck, C. (2002). Enhanced temporal summation of 2nd pain and its central modulation in fibromyalgia patients. *Pain*, 99 (1-2), 49-59.
- Pyszczel, A., Malyszczak, K., Pyszczel, K., Andrzejak, R., & Szuba, A. (2006). Disability, psychological distress and quality of life in breast cancer survivors with arm lymphedema. *Lymphology*, 39(4), 185-192.

- Rausch, S. M., Gramling, S. E., & Auerbach, S. M. (2006). Effects of a single session of large-group meditation and progressive muscle relaxation training on stress reduction, reactivity, and recovery. *International Journal of Stress Management, 13*(3), 273-290.
- Reyes-Gibby, C. C., Duc, N. B., Yen, N. P., Nga, N. H., Van Tran, T., Guo, H., et al. (2006). Status of cancer pain in Hanoi, Vietnam: A hospital-wide survey in a tertiary cancer treatment center. *Journal of Pain and Symptom Management, 31*(5), 431-439.
- Reynolds, J. S. & Perrin, N. A. (2004). Mismatches in social support and psychosocial adjustment to breast cancer. *Health Psychology, 23*(4), 425-430.
- Rietman, J. S., Dijkstra, P. U., Debreczemi, R., Geertzen, J. H., Robinson, D. P., & de Vries, J. (2004). Impairments, disabilities and health related quality of life after treatment for breast cancer: A follow-up study 2.7 years after surgery. *Disability and Rehabilitation, 26*(2), 78-84.
- Roelofs, J., Peters, M., McCracken, L., & Vlaeyen, J. (2003). The pain vigilance and awareness questionnaire (PVAQ): Further psychometric evaluation in fibromyalgia and other chronic pain syndromes. *Pain, 101* (3), 299-306.
- Rosenstiel, A. K. & Keefe, F. J. (1983). The use of coping strategies in chronic low back pain patients: Relationship to patient characteristics and current adjustment. *Pain, 17*(1), 33-44.
- Rumble, M., Keefe, F., Edinger, J., Porter, L., & Garst, J. (2005). A pilot study investigating the utility of the cognitive-behavioral model of insomnia in early-stage lung cancer patients. *Journal of Pain and Symptom Management, 30*(2), 160-169.
- Rummans, T. A., Frost, M., Suman, V. J., Taylor, M., Novotny, P., Gendron, T. et al. (1998). Quality of life and pain in patients with recurrent breast and gynecologic cancer. *Psychosomatics, 39*, 437-445.
- Sammarco, A. (2001). Perceived social support, uncertainty, and quality of life of younger breast cancer survivors. *Cancer Nursing, 24*(3), 212-219.
- Sammarco, A. (2003). Quality of life among older survivors of breast cancer. *Cancer*

Nursing, 26(6), 431-438.

Sapir, R., Patlas, M., Strano, S. D., Hadas-Halpern, I., & Cherny, N. I. (2003). Does mammography hurt? *Journal of Pain & Symptom Management*, 25(1), 53-63.

Savard, J., Simard, S., Blanchet, J., Ivers, H., & Morin, C. (2001). Prevalence, clinical characteristics, and risk factors for insomnia in the context of breast cancer. *Sleep*, 24 (5), 583-590.

Schag, C. A. & Heinrich, R. L. (1990). Development of a comprehensive quality of life measurement tool: CARES. *Oncology*, 4, 135-138.

Seeman, T. E. & Berkman, L. F. (1988). Structural characteristics of social networks and their relationship with social support in the elderly: Who provides support? *Social Sciences and Medicine*, 23, 737-749.

Seminowicz, D. & Davis, K. (2006). Cortical responses to pain in healthy individuals depends on pain catastrophizing. *Pain*, 120 (3), 297-306.

Severeijns, R., Vlaeyen, J., & van den Hout, M. (2004). Do we need a communal coping model of pain catastrophizing? An alternative explanation. *Pain*, 111 (3), 226-229.

Shelbourne, C. D., & Stewart, A. (1991). The MOS Social Support Survey. *Social Science and Medicine*, 32, 705-714.

Sherliker, L. & Steptoe, A. (2000). Coping with new treatments for cancer: A feasibility study of daily diary measures. *Patient Education & Counseling*, 40(1), 11-19.

Sobel, M. E. (1982). Asymptotic confidence intervals for indirect effects in structural equation model. In S. Leinhardt (Ed.) *Sociological Methodology*. San Francisco: Jossey-Bass. 290-312.

Spiegel, D., Sands, S., & Koopman, C. (1994). Pain and depression in cancer patients. *Cancer*, 74, 2570-2578.

Spielberger, C. D. (1977). *State-trait anxiety inventory*. Palo Alto, CA: Consulting Psychologists Press.

Staud, R., Cannon, R., Mauderli, A., Robinson, M., Price, D., & Vierck, C. (2003). Temporal summation of pain from mechanical stimulation of muscle tissue in

- normal controls and subjects with fibromyalgia syndrome. *Pain*, 102 (1-2), 87-95.
- Staud, R., Koo, E., Robinson, M. E., & Price, D. D. (2007). Spatial summation of mechanically evoked muscle pain and painful aftersensations in normal subjects and fibromyalgia patients. *Pain*, 130(1-2), 177-187.
- Staud, R., Robinson, M. E., Vierck, C. J., Cannon, R. C., Mauderli, A. P., & Price, D. D. (2003). Ratings of experimental pain and pain-related negative affect predict clinical pain in patients with fibromyalgia. *Pain*, 105(1-2), 215-222.
- Stevens, P. E., Dibble, S. L., & Miaskowski, C. (1995). Prevalence, characteristics, and impact of postmastectomy pain syndrome: An investigation of women's experiences. *Pain*, 61, 61-68.
- Stomper, P. C., Kopans, D. B., Sadowsky, N. L., Sonnenfeld, M. R., Swann, C. A., Gelman, R. S., et al. (1988). Is mammography painful? A multi-center patient survey. *Archives of Internal Medicine*, 14, 521-524.
- Stone, P., Ream, E., Richardson, A., Thomas, H., Andrews, P., Campbell, P., et al. (2003). Cancer-related fatigue- A difference of opinion? Results of a multicentre survey of healthcare professionals, patients and caregivers. *European Journal of Cancer Care*, 12, 20-27.
- Strang, P. (1992). Emotional and social aspects of cancer pain. *Anta Oncologica*, 31, 323-326.
- Strang, P. & Qvarner, H. (1990). Cancer-related pain and its influence on quality of life. *Anticancer Research*, 10, 109-112.
- Sullivan, M., Adams, H., & Sullivan, M. (2004). Communicative dimensions of pain catastrophizing: Social cueing effects on pain behaviora and coping. *Pain*, 107(3), 220-226.
- Sullivan, M. J., Bishop, S. R., & Pivik, J. (1995). The Pain Catastrophizing Scale: Development and validation. *Psychological Assessment*, 7(4), 524-532.
- Sullivan, M. J., Thorn, B., Haythornthwaite, J. A., Keefe, F. J., Martin, M., Bradley, L. A., et al. (2001). Theoretical perspectives on the relation between catastrophizing and pain. *Clinical Journal of Pain*, 17(1), 52-64.

- Sullivan, M., Tripp, D., & Sanotr, D. (2000). Gender differences in pain and pain behavior: The role of catastrophizing. *Cognitive Therapy & Research, 24* (1), 121-134.
- Tasmuth, T., Kataja, M., Blomqvist, C., von Smitten, K., & Kalso, E. (1997). Treatment-related factors predisposing to chronic pain in patients with breast cancer – a multivariate approach. *Acta Oncologica, 36*(6), 625-630.
- Taylor, K. O. (2004). Morbidity associated with axillary surgery for breast cancer. *ANZ Journal of Surgery, 74*(5), 314-317.
- Thorn, B. E., Clements, K. L., Ward, L. C., Dixon, K. E., Kersh, B. C., Boothby, J. L., et al. (2004). Personality factors in the explanation of sex differences in pain catastrophizing and response to experimental pain. *Clinical Journal of Pain, 20*(5), 275-282.
- Thorn, B., Pence, L., Ward, L., Kilgo, G., Clements, K., Cross, T., Davis, A., & Tsui, P. (2007). A randomized clinical trial of targeted cognitive behavioral treatment to reduce catastrophizing in chronic headache sufferers. *The Journal of Pain, 8* (12), 938-949.
- Uzun, O., Aslan, F. E., Seliman, D., & Koç, M. (2004). Quality of life in women with breast cancer in Turkey. *Journal of Nursing Scholarship, 36*(3), 207-213.
- Vecht, C. J., Van de Brand, H. J., & Wajer, O. J. (1989). Post-axillary dissection pain in breast cancer due to a lesion of the intercostobrachial nerve. *Pain, 38*(2), 171-176.
- Wachelka, D. & Katz, R. C. (1999). Reducing test anxiety and improving academi self-esteem in high school and college students with learning disabilities. *Journal of Behavior Therapy and Experimental Psychiatry, 30*(3), 191-198.
- Ware, J. E. & Sherbourne, C. D. (1992). The MOS 36-item Short Form Health Survey (SF-36): I. Conceptual framework and item selection. *Medical Care, 30*, 472-483.
- Westermann, R., Spies, K., Stahl, G., & Hesse, F. W. (1996). Relative effectiveness and validity of mood induction procedures: A meta-analysis. *European Journal of Social Psychology, 26*, 557-580.
- Willey, C. & Silliman, R. A. (1990). The impact of disease on the social support experiences of cancer patients. *Journal of Psychosocial Oncology, 8*, 79-95.

Wu, H. & McSweeney, M. (2007). Cancer-related fatigue: "It's so much more than just being tired." *European Journal of Oncology Nursing*, 11(2), 117-125.

Zimet, G. D., Dahlem, N. W., Zimet, S. G., & Farley, G. K. (1988). The Multidimensional Scale of Perceived Social Support. *Journal of Personality Assessment*, 52, 30-41.

Biography

Cindy Scipio was born April 15, 1979 in Brooklyn, New York. She received her Bachelors of Arts with dual majors in biology and psychology from the University of North Carolina-Chapel Hill in May 2001. She began the doctoral program in clinical psychology at Duke University in 2002 and received her Masters of Arts in Psychology from Duke University in May 2007. As a graduate student, she published the following book chapters and articles:

- Campbell, L.C., Andrews, N., Scipio, C., Flores, B., Feliu, M.H., Keefe, F.J. (in press). Pain coping in Latino populations. *Journal of Pain*.
- Dixon, K., Keefe, F., Scipio, C., Perri, L., Abernethy, A. (2007). Psychological interventions for arthritis pain management in adults: A meta-analysis. *Health Psychology, 26*(3), 241-250.
- Campbell, L.C., Keefe, F.J., Scipio, C., McKee, D.C., Edwards, C.L., Herman, S.H., Johnson, L.E., Colvin, O.M., McBride, C.M., & Donattuci, C. (2007). Facilitating research participation and improving quality of life for African American prostate cancer survivors: A pilot study of telephone-based coping skills training. *Cancer, 109* (2) *Supplement*, 415-424.
- Keefe, F.J., Scipio, C., Perri, L. (2006). Psychosocial approaches to managing pain: Current status and future directions. In Gifford, L. (Ed.). Topical Issues in Pain.
- Keefe, F.J., Ahles, T.A., Sutton, L., Dalton, J., Baucom, D., Pope, M.S., Knowles, V., McKinstry, E., Furstenberg, C., Syrjala, K., Waters, S., McKee, D., McBride, C., Rumble, M., Scipio, C. (2005). Partner-guided cancer pain management at the end of life: A preliminary study. *Journal of Pain and Symptom Management, 29* (3), 263-272.
- Matchar, D.B., Keefe, F.J., McCrory, D.C., Scipio, C.D., Cooper, K., Kolimaga, J.T., Huntington, A.C. Technology assessment on the use of behavioral therapies for treatment of medical disorders: Part 1- Impact on management of patients with diabetes mellitus. Report to the US Agency for Healthcare Research and Quality. Duke Center for Clinical Health Policy Research, Durham, North Carolina: February 9, 2004.
- Abernethy, A.P., Keefe, F.J., McCrory, D.C., Scipio, C.D., Matchar, D.B. Technology

assessment on the use of behavioral therapies for treatment of medial disorders:
Part 2- Impact on management of patients with cancer pain. Report to the US
Agency for Healthcare Research and Quality. Duke Center for Clinical Health
Policy Research, Durham, North Carolina: June 10, 2004.

Keefe, F.J., Rumble, M.E., Scipio, C.D., Giordano, L.A., Perri, L.M. (2004). Psychological
aspects of persistent pain: Current state of the science. *Journal of Pain*, 5 (4), 195-
211.