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Factors contributing to disability in a chronic low back pain population: A comprehensive analysis using continuous ambulatory monitoring

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Factors Contributing to Disability in a Chronic Low Back Pain Population:

A Comprehensive Analysis Using Continuous Ambulatory Monitoring

by

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DEDICATION

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ABSTRACT

Disability in chronic low back pain patients has been established as a function of variables across three areas: pain, cognitive-behavioral variables, and social variables. New technology has improved the ability to accurately measure physical activity, a significant component of disability, through the use of actigraphy for real-time ambulatory monitoring. The current study assessed between and within patient changes in physical activity as a function of current pain, anticipated pain, pain sensitivity, depression, pain anxiety, catastrophizing, and significant others' responses. Time-series and ordinary least squares regression analyses of 20 participants revealed that patients change their physical activity based on both their current experience of pain and their anticipation of future pain. Additionally, patients differ in amount of activity based on their sensitivity to pain, fear of pain, and receiving solicitous responses to their pain from a significant other. The results support the fear-avoidance model of pain through multiple findings: (1) some patients escape from current pain by decreasing activity; (2) some patients avoid future pain by engaging in low levels of activity when they anticipate their pain could worsen; (3) patients with higher sensitivity to pain engage in less physical activity; (4) patients who endorse more beliefs that their pain is harmful engage in less physical activity; and (5) patients whose significant others are overly responsive to the pain and inadvertently reinforce beliefs that pain is harmful also engage in less activity. However, a strength of this study was the ability to simultaneously analyze a wide variety of theoretically-based predictors. Results of this comprehensive analysis revealed that variables from the Social Model accounted for a statistically significant amount of the variance in physical activity. These results are particularly meaningful given that increase in physical activity is a core component of many

treatments for chronic low back pain. By better understanding the variables that impact

physical activity in low back pain patients, clinicians can more accurately assess patients and

intervene more effectively.

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INTRODUCTION

Back pain is one of the most common problems treated in the United States health care system, affecting 2%-5% of the population at any one time, 26%-27% over any 3-month period, and 70%-80% over the course of their lifetime (Garofalo & Polatin, 1999; Strine & Hootman, 2007; National Center for Health Statistics, 2006). The financial cost of back pain is high: patients with one low back pain incident incur medical costs of $3,718 annually, rising to $4,805 after a second incident, $5,874 for three to five incidents, and $6,888 after at least six episodes (Ritzwoller, Crounse, Shetterly, & Rublee, 2006). Moreover, back pain is the most common cause of disability in people 45 and under, causes 4% of people to change employment, and is a problem most severe in industrialized nations (Garofalo & Polatin, 1999). The impact of low back pain disability on work is significant, as an estimated 22% of chronic low back pain patients are on some form of medical leave from work and another 11% work in a reduced capacity (Wynne-Jones, Dunn, & Main, 2008). Finally, 17% of patients who are on work disability go on recurrent work disability, with patients incurring 69% of their total lost work time and 84% of their total medical costs after the recurrence of their pain problem (Wasiak, Kim, & Pransky, 2006).

Pain is traditionally categorized as acute or chronic. Most individuals initially suffer from *acute pain*, indicating the pain was the result of an injury or damage (Geisser, Roth, & Williams, 2006). *Chronic pain* represents pain that has lasted at least 3 months (von Korff, 1999; Turk & Okifuji, 2001; Thorn, 2004). On occasion, chronic pain does not result from injury, but rather has an insidious gradual onset over time (Thorn, 2004).

It is common for chronic back pain patients to have endured numerous types of treatment without success and have significantly altered their lives (Vasudevan, 1992).

When the lifestyle changes become significant, some individuals become *disabled*.

Disability can be understood as a significant inability to engage in meaningful and necessary

activities in one's daily life (Battié & May, 2001). Such disability is not limited to back pain

patients, as individuals may become disabled from other medical conditions or cognitive

disabilities.

The following sections describe the complex phenomenon of chronic low back pain

and related disability. A unique aspect of the study presented later in this manuscript is the

use of relatively new technology to assess disability as the primary dependent variable.

Thus, the introduction of this paper begins with a description of disability and the ways in

which it is measured. This is followed by a description of a variety of sensory and

psychosocial variables that may contribute to differences in degree of disability.

Disability Defined

The focus of the present paper is on the identification of determinants of disability in

the chronic back pain population. Unfortunately, studying disability is complex, as it is a

concept that is difficult to operationally define. Disability has two primary components: The

first is quantity of activity, such that disabled individuals typically experience a reduction in

quantity of activity or physical ability (e.g., range of motion, lifting capacity) relative to their

level in non-pain states (Polatin & Mayer, 2001; Battié & May, 2001). The second is the

value of the activity to the individual, such that disabled individuals demonstrate an inability

to engage in meaningful activities (Battié & May, 2001). This highlights individual

differences, a key element to describing why two individuals in a similar situation may have

vastly different levels of disability (Millard, Wells, & Thebarge, 1991). Moreover, it

explains why some individuals are particularly bothered by an inability to do a specific

activity, while others do not mind, as the motivation to cope with chronic pain is based on the

desire to return to a meaningful and valued life (Van Damme, Crombez, & Eccelston, 2008).

Thus, one aspect of disability can be measured quantitatively, while the other mixes in the

more qualitative meaning to the patient of the activities that can no longer be performed. As

a result, how one conceptualizes disability can vary significantly and has resulted in a variety

of theoretical models of disability.

The multiple variables that compose this disability construct make it difficult to both

operationalize and assess disability. The result has been a wide variety of disability

measures, including self-report questionnaires, clinical tests, and daily activity monitoring,

that attempt to assess the level of disability in pain patients. Each form of assessment has

unique strengths and weaknesses in assessing various components of disability. As is

demonstrated in the following review, no single assessment comprehensively evaluates all

dimensions of disability. Thus, it is important to consider what each assessment does

evaluate, as that information can uniquely influence the inferences clinicians and researchers

make about disability.

Self-report questionnaires and clinical interviews. Self-reports of symptoms,

collected through questionnaires and interviews, are the most commonly used disability

assessment methods. Some questionnaires require participants to self-report activities that

can no longer be completed and indicate how that affects their daily life. These

questionnaires range in breadth from assessing general disability regardless of source, to

condition-specific disability, and of particular relevance to this study, disability associated

with experiencing back pain. A commonly used questionnaire that targets pain patients in

general is the Pain Disability Index (Pollard, 1984), while the Quebec Back Pain Disability Scale (Kopec, Esdaile, Abrahamowicz, Abenhaim, Wood-Dauphinee, et al., 1995), Oswestry Disability Index (Fairbank, Couper, Davies, & O'Brien, 1980), and Roland and Morris Disability Scale (Roland & Morris, 1983) are oriented more specifically to the back pain population.

As will be discussed extensively later in this introduction, psychosocial variables are often considered together as one component of theoretical models of disability. Questionnaires and clinical interviews are also used to assess the psychosocial variables that may be related to disability. For example, such assessments may target psychological variables, such as depression, anxiety, stress, pain beliefs, coping styles, personality variables, and social or interpersonal variables (Bradley & McKendree-Smith, 2001; DeGood & Tait, 2001; Romano & Schmaling, 2001; Jacob & Kerns, 2001). In all situations, the benefit of using questionnaires comes from their unique ability to both identify the way the patient's disability affects his or her life, and identify the way psychosocial variables in the patient's life influence the patient's disability levels. The collection of this broad set of information is indicative of the multidimensional view of disability, as it goes beyond simply identifying physical problems.

Questionnaires and interviews present both advantages and disadvantages. Validated questionnaires allow for the repeated measurement of identical variables, allowing researchers and clinicians to identify changes over time (Romano & Schmaling, 2001). Self-report questionnaires are further beneficial in their assessment of disability across a wide variety of domains. However, self-report questionnaires may suffer from inaccuracies (Kop, Lyden, Berlin, Ambrose, Olsen, Gracely, et al., 2005; Lee, Simmonds, Novy, & Jones,

2001). For example, individuals may disproportionately remember extreme or recent symptoms (e.g., recency effect), may endorse items in a specific manner due to the interference of psychiatric symptoms, or may respond in a way that reflects a social desirability bias. Thus, investigators must consider that self-report instruments gather valuable information about the meaning of a patient's symptoms to his or her life, but must also be cautious to recognize the presence of biases in the patient's report.

In summary, self-report assessments provide a useful set of information that is unattainable through other assessment methods. Investigators must continue to employ self-report questionnaires and clinical interviews as part of their assessment process in an effort to fully understand the patient's perspective of his or her level of disability. However, given the problems with self-report assessments, researchers would be remiss in relying solely on such assessments. The following subsections highlight additional forms of disability assessment: clinical tests and activity monitoring.

Clinical tests. Clinical tests demonstrate, in a more objective fashion, the ability of an individual to engage in specific physical activities (Polatin & Mayer, 2001). Examples of these tests include functional capacity evaluation testing (Geisser, Robinson, Miller, & Bade, 2003; Battié & May, 2001); range of motion testing, trunk strength testing, aerobic capacity testing, task-specific tests (Polatin & Mayer, 2001); and lifting tasks (Smeets, Hidra, Keser, Hitters, & Knotternus, 2006; Polatin & Mayer, 2001). These tests are indicative of an individual's ability to perform movements or engage in specific activities, providing objective ability-oriented information that describes an important aspect related to a patient's level of disability.

As with all forms of assessment, clinical tests provide unique advantages and disadvantages in the assessment of disability. Polatin and Mayer (2001) note that clinical tests are more objective than the more commonly used self-report methods. Thus, whereas self-report assessments reflect an individual's perception of his or her ability, clinical tests may be more indicative of actual physical ability. However, the clinical nature of these tests, as opposed to naturalistic observations, as well as the relatively narrow sample of behavior assessed, prevents the results of clinical tests from being representative of daily life (Lee et al., 2001). Additionally, some have suggested that such tests are influenced by the amount of effort a patient is willing to expend (Geisser, Robinson, et al., 2003). Thus, the results of clinical tests may be more indicative of the patient's level of effort than his or her actual physical ability. Finally, it is important to consider that activity limitations only represent one aspect related to disability. The *ability* to engage in tasks may be separate from the *value* to the participant in engaging in these activities. As with other forms of assessment, clinical tests alone do not appropriately assess disability; they must be used in concert with other assessment methods.

Daily activity monitoring. Daily activity monitoring, either by journaling or electronic monitoring, requires individuals to quantify how much they engage in activities of daily living. This type of measure is intended to identify the quantity of activity in an individual's day and may extend to include contextual information as well. However, such monitoring is prone to be undermined by poor compliance with recording (Stone, Shiffman, Schwartz, Broderick, & Hufford, 2003) and may be limited simply to quantitative measurement in the absence of contextual information. Responses may also be altered due to social desirability.

The literature contains multiple studies on compliance in daily activity monitoring. An exemplar study employed an electronic sensor in a paper notebook to track compliance with the recording task (Stone et al., 2003). Despite the fact that participants stated that they complied 90% of the time, the sensor revealed compliance was only 11%. On 32% of the days, the notebook was not even opened. Thus, the measurement of activity through paper diary reports appears to be significantly confounded. These same investigators also demonstrated that with electronic diaries compliance tripled, to a compliance rate of 94%. These results suggest that the use of electronic diaries benefit from technological advancements that make individuals more compliant with their recording tasks.

A recent review compared 34 physical activity assessment instruments broadly categorized as electronic measurement devices, questionnaires, and diaries (Verbunt, Huijnen, & Koke, 2009). The authors suggest electronic measurement devices (referred to as movement registration) as the superior form of measurement. Specifically, they recommend the use of accelerometers for measurement due to their high validity, objectivity, and unobtrusiveness.

Summary of disability assessment. As a result of the variety of disability measurements and the pros and cons of each, no consensus on disability measurement is present in the study of chronic back pain disability. Thus, the reader must bear in mind that the body of literature referenced in the following summary of chronic back pain disability theories incorporates a set of research that varies considerably in methods of disability measurement. Most, however, incorporate multiple strategies in an effort to capture multiple facets of disability. Although the body of research as a whole demonstrates the presence of numerous, significant psychosocial predictors of disability, it is difficult to ascertain which

predictors are the strongest, as the mix of disability measures with subsets of predictors yields a body of literature that can sometimes appear more heterogeneous than most would desire.

Causes of Chronic Back Pain

Disability, as defined in the previous section, is a problem that plagues the chronic back pain population. The perceived relationship between disability and the presence of pain suggests that disability may either contribute to or emanate from the experience of persistent back pain. Prior to exploring the relationship of disability and pain, one must consider why patients suffer from pain initially and over a longer, chronic period.

Unfortunately, the etiology of chronic back pain has perplexed researchers (Devor & Tal, 2009). The subsections below discuss the presence of pain in terms of two major areas of study: (1) injuries and physical dysfunction; and (2) changes in the central nervous system. The complexity of identifying sources of pain in chronic back pain patients will be described as a complicating factor in establishing the relationship between disability and pain.

Injuries and physical dysfunction. In the acute phases, hypotheses often postulate that the presence of pain originates from an injury or physical deformity. As a result, many in the medical community are drawn to diagnostic imaging (e.g., x-rays, CT scans, MRI) as means of identifying physical injury that is causing pain. Unfortunately, in chronic pain patients, such diagnostic imaging is often unable to accurately detect sources of pain. Investigators report that 70%-90% of patients with chronic back pain have no identifiable structural source of their pain, while patients with no pain symptoms often have structural

pathology that would be expected to cause pain (Waddell & Turk, 2001; Turk & Flor, 1999; Geisser, 2007).

Changes in the central nervous system. Modern medicine has exposed possible reasons for the absence of an identifiable physical source of pain in chronic pain patients. Recent research has identified central sensitization and central augmentation as etiological mechanisms for the continued presence of pain. Central sensitization, central augmentation, and the research related to their discovery is reviewed below. The subsection ends with a description of how the mechanisms affect chronic pain patients specifically.

Central sensitization refers to a reorganization of the central nervous system that results from the prolonged experience of neuropathic or musculoskeletal pain (Geisser, Haig, Tong, Yamakawa, Quint, Hoff, et al., 2007; Coderre, Katz, Vaccarino, & Melzack, 1993). Thus, this phenomenon presents prolonged pain as a residual of having been in pain, now controlled within the central nervous system, rather than at the actual site on the body that originally produced pain. Central sensitization has been exemplified through studies of phantom limb pain. For example, Melzack and colleagues (2001, 2004) use the neuromatrix theory of pain to explain the reorganization of the neural network in phantom limb pain sufferers such that peripheral stimulation in an adjacent area can result in sensations in the nonexistent limb. The neuromatrix theory suggests that pain is not simply the result of sensation but is also the result of a complex neural network that draws on previous experience to influence future experience. Thus, the brain of a patient who once suffered from pain due to an injury has reorganized to expect painful sensations in that area. As a result, it could be suggested that feeling pain results from a combination of actual sensory experience and the aftereffects of changes in the neural matrix.

A related but slightly different theory of centralized responses to pain is that of central augmentation. Whereas central sensitization is attributed to persistent pain and specific to pain, central augmentation is a genetic predisposition to have abnormal sensory processing of many sensations, including hyperalgesia. For example, differences in catecholamine-O-methyltransferase (COMT) were recognized as significantly related to the level of pain, suggesting a biological origin for central augmentation (Diatchenko, Slade, Nackley, Bhalang, Sigurdsson, Belfer, et al., 2005). Central sensitization and central augmentation have been explored most extensively for fibromyalgia sufferers, as they appear to have greater sensitivity to stimuli, as demonstrated by a greater sensitivity to auditory stimulation relative to healthy controls (Geisser, Glass, Rajcevska, Clauw, Williams, Kileny, 2008). These results suggest that fibromyalgia patients suffer from central augmentation, as a sensitivity to sounds represents a generalized heightened sensory awareness that extends beyond what would be expected with central sensitization of pain.

In general, the literature on centralized responses to pain does not distinguish between central sensitization and central augmentation. A heightened awareness to pain attributed to the central nervous system could be pain-specific, as in central sensitization, or part of a generalized hypersensitivity, as in central augmentation. Studies of patients suffering from fibromyalgia, chronic fatigue syndrome, and lumbar spinal stenosis all revealed heightened brain responses to painful stimuli relative to healthy controls (Geisser, Strader Donnell, Petzke, Gracely, Clauw, & Williams, 2008; Giesecke, Gracely, Grant, Nachemson, Petzke, Williams et al, 2004; Gracely, Petzke, Wolf, & Clauw, 2002). Additionally, similar brain changes have been evident across chronic pain problems, including chronic back pain (May, 2008). As a result, the broad conclusion about a centralized response to pain is that the

presence or absence of chronic pain may be due to differences in the central nervous system's response to the prolonged experience of pain, not differences at the actual site of the patient's pain (Geisser, Haig, et al., 2007). This may serve to explain the difficulty in identifying sources of pain through diagnostic imaging and other techniques: the injury that initially caused acute pain may have healed, but the sensation of pain remains due to this centralized response.

Summary. The poor sensitivity and specificity of diagnostic imaging, as well as phenomena like central sensitization and central augmentation, reveal why clinicians are often unable to identify a specific injury that may be causing a patient's painful symptoms. The reality of the situation is that pain is only one element that may contribute to disability. Many other correlates of disability now receive the majority of attention in the chronic back pain literature. Despite the fact that studying the correlates of chronic back pain prohibits the ability to make definitive causal attributions, the research on correlates has yielded numerous unidirectional and bidirectional causal theories. The following sections detail the numerous theories of chronic back pain that have been developed and relate these theories to disability in the chronic back pain population.

Pain

The previous section described the difficulty in identifying the source of pain in chronic pain patients. Unfortunately, this inability to detect sources of pain is contradictory to the common human expectation that the presence of pain is evidence of an injury: When an individual is initially confronted with pain, such as occurs through injury, he or she automatically makes associations between immediately preceding or co-occurring stimuli or

behaviors and the presence of pain (Turk, 1996; Vlaeyen & Linton, 2000). Through one or

more similar pairings, the individual learns to associate pain with these stimuli or behaviors

as exemplified in the following example (Vlaeyen & Linton, 2000): Consider the patient

who initially feels pain after bending to pick up a heavy box. When this injury occurs, a

reaction of pain and sympathetic activation ensues. The patient may associate bending with

pain and sympathetic activation (fear, anxiety, muscle tension). For an *acute* period of time

this recognition is useful, as the individual identifies a threat of future injury and, typically,

chooses to avoid that behavior (Turk & Flor, 1999). Thus, this is an adaptive or protective

behavior that follows injury. At some point the injury heals and the adaptive function of this

behavior diminishes. The continued experience of pain at this point is what constitutes the

problematic aspects of chronic pain.

  Relationship of pain and disability. When an individual continues to experience

pain beyond the acute period, he or she is presented with a dilemma. Theoretically, the

injury should be healed and there should be no need to continue to rest or protect the body

from future injury. However, the continued presence of pain signals to the individual that he

or she should continue to rest in an effort to heal. Dysfunctional patients are those who

continue to restrict their activity at an abnormally high and disruptive level.

  The assumption that pain continues to indicate the presence of an injury emanates

from the traditional medical model. This model suggests that the identification of a physical

source of pain (e.g., injury) must be found, suggesting that "secondary" factors, such as

disability or psychological problems, would simply diminish with a reduction in pain. This

exemplifies the mind-body dualism that was dominant in medical care until the more recent

advancements of biopsychosocial models (Gatchel, 1999). Presently, mind-body dualism is no longer accepted as an appropriate theoretical model.

One reason to question the dualistic approach is the difficulty in scientifically proving that painful sensations are actually the direct cause of differences in activity level and that disability is simply secondary to the presence of pain (Waddell & Turk, 2001; Vasudevan, 1992). Much of the difficulty in assessing the pain-disability relationship is the difficulty in understanding individual differences in perception of painful sensations. The following subsections describe these difficulties, providing the context for the remainder of this paper, which extends beyond pain to focus on factors within the biopsychosocial model that contribute to disability in the chronic back pain population.

Measuring pain. The most difficult aspect of studying pain is that it is a "private experience" (Geisser, Casey, Bruckbsch, Ribbens, Appleton, & Crofford, 2003; Jensen & Karoly, 2001; IASP, 1994). As such, it is only possible to determine how much pain an individual *perceives* that he or she is experiencing. This reveals a primary problem with pain measurement: Individual pain ratings do not yield any useful information about the source or severity of the patient's pain problem. Investigators and clinicians are unable to determine that a patient with extreme pain is suffering from a problem that is any worse than a patient who is suffering from minimal pain. The differences may be rooted in how individuals interpret the painful sensation or what individuals use as the yardstick to which they relate current pain to past painful experiences, such as kidney stones, childbirth, or post-surgical pain. Thus, the assessment of pain may simply be a description by the patient of how this pain compares to other pain that he or she has experienced. This is further evidenced in studies that have demonstrated that the interpretation of pain is a combination of one's

expectations and the actual sensory experience (Brown, Seymour, Boyle, El-Deredy, & Jones, 2008). However, it is unclear whether expectations about pain influence the actual experience of pain or simply how one rates his or her pain (Wager, 2005).

The assessment of pain is commonly conducted through asking the patient to categorize his or her pain or rate the pain on visual analog scales, verbal rating scales, or numerical rating scales (Chapman, Casey, Dubner, Foley, Gracely, & Reading, 1985; Jensen, Karoly, & Braver, 1986; Jensen & Karoly, 2001). The meaning of the resulting ratings are impossible to determine, as there is no way to assess the reliability or validity of individuals' estimations of their pain levels (Turk & Melzack, 2001). Moreover, pain ratings have questionable utility, as they are hindered by variations between individuals on a variety of variables, such as experiences, situations, personality variables, psychosocial variables, behavioral contingencies, and variations in sensitivity to pain (Turk & Melzack, 2001). As a result, studies rarely simply assess pain ratings in the absence of other variables.

Experimental pain. Considering the limitations in assessing actual pain, some investigators use the psychophysical approach of experimentally inducing pain in research participants through heat, pressure, and electrical stimulation (Geisser, Gracely, Giesecke, Petzke, Williams, & Clauw, 2007; Chapman et al., 1985). By inducing pain, investigators know that each patient is receiving the same objective physical stimulus that is intended to cause a painful sensation. Thus, these methods reveal how patients differentially interpret the same painful stimulation.

Experimental pain studies have been conducted to determine pain perception in both healthy participants and chronic pain participants. These studies commonly utilize pain threshold tests, when a painful stimulus is applied by an experimenter or clinician in a benign

location and the patient indicates the point at which the sensation goes from "not painful" to "painful" (Chapman et al., 1985) or the patient indicates the amount of pain he or she feels (Price, Riley, & Wade, 2001).

However, it is unclear that the pain ratings patients use to describe painful experimental stimuli are related to pain ratings they use to describe clinical pain, the term used to describe the pain that patients experience as part of their daily lives. This uncertain relationship between experimental and clinical pain raises questions concerning the use of experimental pain to predict or explain clinical pain (Geisser, Gracely, et al., 2007). This is particularly true when considering how expectancies may affect research participants' responses to pain and may alter their interpretation of the meaning of their pain (Price et al., 2001). Specifically, a patient in an experimental study will both expect a painful sensation and understand that the sensation will be temporary and unlikely to be harmful in any way. In contrast, a patient experiencing clinical pain might feel the pain unexpectedly and could interpret the painful sensation as threatening. For example, patients with back pain resulting from an injury may interpret painful sensations in daily life as indicative of further injury.

The effects of the predictability of painful stimuli in experimental settings has been addressed in the literature. Geisser and colleagues (2007) compared two procedures for delivering pressurized pain to participants. The multiple random staircase procedure involves the delivery of pressurized painful stimulation in random amounts, under the premise that the random delivery will prevent participants from being able to anticipate the next level of pain. Alternatively, dolorimetry involves the delivery of pressurized painful stimulation without randomization, which may allow participants to anticipate the severity of the upcoming painful stimulation. Thus, this study compared a predictable method of

delivery against an unpredictable method. Despite the difference in methodology, the results indicated that both significantly related to clinical pain intensity. These new results suggest that specific types of experimental pain, such as pressure induced pain, may be useful in research, though further research is needed in this area to determine the relative effectiveness of different types of experimentally induced pain and the best method for delivering such stimulation.

In summary, the relationship between experimentally induced pain and clinical pain remains unclear, as the literature contains varying levels of support for the relationship of experimental and clinical pain. Differences in the predictability of painful stimuli (e.g., experimental pain is more predictable than clinical pain), as well as the location of pain (e.g., experimental stimuli are commonly presented in benign locations), highlight significant differences between experimental and clinical pain. Recent research on the random staircase method indicates that experimental pain may still be useful in the study of chronic pain, though further research is needed.

Anticipating pain. The debilitating effects of experiencing pain are evident. However, half a century of research has indicated that experiencing pain may not be the direct cause of disability. Instead, after experiencing pain, it may be the way one cognitively processes the possibility of being in pain again in the future that produces its own detrimental results. Much of the rest of this paper focuses on the interaction of such psychosocial variables with disability.

To understand the role of anticipation of pain in resulting disability, one must consider pain within a behavioral context: Pain is experienced as an aversive stimulus. Individuals typically seek to avoid aversive stimuli, as it is rewarding to avoid having the

aversive stimulus occur. Thus, when individuals expect the presence of painful stimuli, they are expecting the presentation of an aversive stimulus, something they would prefer to avoid. To avoid being in pain, people have to avoid physical activities that are anticipated to be pain-producing. Using this conceptualization, Vlaeyen and colleagues (2000) have led the field in describing disability in the chronic back pain population. Their research conceptualizes the avoidant behavior as pain-related anxiety. Correlates of this behavior include mood-related responses, as well as social or environmentally-based factors. The fear-avoidance model and related psychosocial research is reviewed extensively in the following section.

Summary of pain models. In traditional models, pain was considered to be the direct cause of disability. The inability to accurately measure pain levels has consistently resulted in poor correlations between pain and disability (Waddell & Turk, 2001; Vasudevan, 1992). The result has been the exploration of other variables outside of simply pain intensity. Within the pain realm, this has included experimentally induced pain, which allows researchers to consider variables related to pain perception and sensitivity. However, the more common trend in the literature is to consider all of the ways that pain influences individuals' lives. For example, the ways that the anticipation of being in pain affects individuals has the potential to be as detrimental as does simply the intensity of pain. The following sections illuminate the exploration beyond pain, by describing the research on how psychosocial factors influence disability. Thus, the focus extends beyond how much pain the patient feels to how being in pain and even expecting to be in pain influences the patient's level of disability.

Overview of Psychosocial Models

In response to the difficulty in understanding the relationship between painful sensations and disability, recent research has focused on the relationship between disability and psychosocial correlates of being in pain. Not surprisingly, this relationship is significant, as psychosocial factors are estimated to account for as much as 90% of the variance in physical performance in the chronic pain population (Rudy, Lieber, Boston, Gourley, & Baysal, 2003). This lends strong support to the biopsychosocial model, a theory that has been developed considerably and become more widely accepted over the past 40 years.

Rise of the biopsychosocial perspective of chronic back pain. As discussed in the prior section on pain, experiencing painful sensations was long considered to be a biological phenomenon (Gatchel, 1999). This is exemplified by the fact that pain is the most common reason that people seek medical treatment (Turk & Melzack, 2001). Patients seeking treatment through a medical provider are likely oriented toward biomedical models that explain pain through sensory pathways and have focused the treatment of pain on physical problems (Hardin, 2004). Thus, back pain was typically treated through a disease model, which depends on the diagnosis of a biological problem through identifying physical damage or impairment (Fordyce, 1976; Turk, 1996). Within this model, psychological correlates of pain were viewed as reactions to the pain problem, assumed to disappear when pain was relieved. The only role for psychologists was to treat patients who demonstrated what some termed *psychogenic pain*, essentially psychologically derived or fake pain (Fordyce, 1976; Thorn, 2004).

However, medical providers across disciplines are now joining psychologists in recognizing that identifiable physical problems do not adequately explain patients' pain

complaints. This is particularly true with chronic back pain patients, who demonstrate only moderate relationships between their physical symptoms and their reports of pain, disability, and psychological correlates (Turk, 1996). The inability of biomedical models to fully explain the pain experience has led to the development and acceptance of theories of pain that extend beyond biological explanations.

  Gate Control Theory. The first conceptualization to move beyond a biological focus was the Gate Control Theory of pain, which postulated the combined contribution of psychological and biological factors involved in the experience of pain (Melzack & Wall, 1965; Gatchel, 1999; Turk, 1996). This model indicated that the perception of pain was more than simply a reflection of the sensation on the skin. Instead, they hypothesized that the pathway from the skin's surface to the brain was interrupted by numerous "gates" that provided opportunity for the disruption of the pain signal. Thus, painful sensations can be disrupted by other factors through the sensation pathway, as well as descending inhibitory impulses from the brain. This last component of the theory, "downward mediation" (Gatchel, 1999), allowed for the conceptualization of a psychological aspect of pain, whereby psychological factors could actually influence pain perception, rather than simply being a reaction to being in pain (Turk, 1996).

  As a whole, the model conceptualized pain perception as an integration of sensory-discriminative, motivational-affective, and cognitive-evaluative systems (Melzack & Katz, 2001). This conceptualization effectively differentiates nociception, the automatic physiological system that signals the brain that a painful stimulus is present, and pain, which is the conscious perception of the sensory information (IASP, 1994; Turk, 1996; Boothby, Thorn, Stroud, & Jensen, 1999). Specifically, the model proposes that the spinal cord

transmission from the site of painful stimulation to the brain encounters numerous

opportunities to modulate the painful sensation (Melzack & Wall, 1965; Melzack & Katz,

2004). More recent research by Melzack (Melzack 2001; Melzack & Katz, 2004) has

focused specifically on details related to the brain processes that influence chronic pain, such

as the neuromatrix theory of pain, which was described in the Pain section above.

The Gate Control Theory's greatest value, however, was that it moved the

conceptualization of chronic pain away from the disease model and its focus on an

identifiable biological problem to an illness model that focuses on the individual's

interpretation of having a disease (Turk, 1996; Gatchel, 1999). Despite imperfections in the

Gate Control Theory, it inspired the development of new models that extend beyond physical

pathology to also incorporate social and psychological aspects. The timing of the

development of the Gate Control Theory coincided with the ascension of the biopsychosocial

model, an integration of biological, psychological, and social variables as important

contributing factors in medical problems. The biopsychosocial model leads us to the present

day conceptualization of pain, wherein researchers explore cognitive-behavioral and social

correlates of pain along with the biological elements of injury and structural deformity.

Unique contribution of Wilbert Fordyce. Following on the heels of the Gate

Control Theory's unique contribution of establishing pain as a multidimensional occurrence,

Wilbert Fordyce established the behavioral and social framework for the psychological

conceptualization of pain (Fordyce, 1976; Gatchel, 1999). Fordyce's contribution can be

summarized in two categories: First, he focused on pain behaviors, the way one acts in

response to experiencing painful stimuli. Second, he focused on social factors, examining

how the operant contingencies in a person's life serve to maintain chronic pain behaviors and disability.

Fordyce's focus on pain behaviors was the first attempt to find an alternative focus to the more subjective pain intensity levels that are at the core of the traditional biomedical perspective. Thus, Fordyce's conceptualization of pain behaviors is rooted firmly in behavioral theory, which postulates a patient's observable response to pain is the core focus of the pain problem. The focus on pain behaviors does not suggest that the sensation of pain is unimportant but instead emphasizes that individuals respond differently to pain and that it is the engagement in excess pain behaviors that may be the most distressing aspect of being in pain (Gatchel, 1999).

The behavioral element of Fordyce's theory has led to a behaviorally-oriented set of assessments and treatments in chronic pain. Pain assessments now commonly include the identification of pain behaviors such as guarding, grimacing, inactivity, statements about pain, and reliance on pain-relieving devices (Gatchel, 1999). Behavioral treatments utilize operant strategies to promote "well behaviors" to replace pain behaviors.

Fordyce's theory also places specific importance on social mechanisms as sources of reinforcement for pain behaviors. He postulated that one of the primary reasons people continue to engage in pain behaviors is that others are responsive to their pain, inadvertently reinforcing the presence of pain behaviors by paying attention to the patient when the patient exhibits pain behavior (Fordyce, 1976). Such social reinforcement is commonly provided by the patient's significant other or medical care provider. As a result, Fordyce suggested that the strategic use of attention should be central to operant treatments in chronic pain. Assuming that paying attention to the patient's pain reinforced engaging in pain behaviors,

family members were taught to ignore outward displays of pain behaviors, while being attentive to well-behaviors. The intention was to change the operant mechanism, using the same reinforcement (attention) to reinforce a new, alternative set of behaviors. Fordyce (1976) reports significant successes using this protocol.

Impressively, Fordyce's conceptualization of pain, as well as his treatment methods, still holds merit today. The present biopsychosocial literature on chronic pain either directly or indirectly cites the principles he promoted. As a result, two broad areas of research have developed. The first is the cognitive-behavioral set of research, which explores the behaviors and cognitions that correlate with chronic pain. The focus of this research is on identifying the behaviors and thoughts that either result from chronic pain or lead to the maintenance of painful experiences, suggesting they are integral to the presence of disability in the chronic pain population. The second set of research focuses on the operant mechanisms that reinforce the presence of pain behaviors and cognitions. This research on social mechanisms focuses on attention and other sources of reinforcement that maintain chronic pain behaviors in the way that Fordyce suggested in his groundbreaking research. The cognitive-behavioral and operant perspectives of chronic pain reflect the psychological and social development of the biopsychosocial model, accompanying the more biologically oriented aspects of painful sensations and physical abnormalities. The following sections describe the recent research regarding cognitive-behavioral and social models of chronic pain.

Cognitive-behavioral Models

Cognitive-behavioral models of chronic pain together represent one important conceptual category in the psychosocial conceptualization of chronic pain. These theories

describe the way a patient thinks about pain (cognitions), as well as how the patient reacts to pain (behaviors). The most common areas of focus in cognitive-behavioral models are depressive symptoms, pain beliefs (including catastrophizing and coping styles), and fear-avoidance behaviors.

Depression. Depressive symptoms are broadly categorized in psychology into two categories: somatic-vegetative or cognitive-affective (Turk & Okifuji, 1994). The somatic-vegetative symptoms include psychomotor agitation or retardation, weight gain or loss, and sleep disturbance. The cognitive-affective symptoms include pervasive sadness, feelings of worthlessness, hopelessness, and guilt, and loss of interest.

The somatic-vegetative symptoms of depression run parallel to symptoms common in the chronic pain population (Turk & Okifuji, 1994). For example, depressed patients often display sleep difficulties due to their mood problem, while back pain patients also have sleep difficulties, typically attributed to discomfort. Similarly, depressed patients often have changes in appetite and changes in weight, while pain patients experience appetite and weight changes as well. Given this issue, it is difficult to diagnose depression in back pain patients. Depressive symptoms could be a sign of depression, but they could also be a coincidence, medical symptoms, side-effects of medications, or a secondary reaction to being in pain (Turk & Okifuji, 1994).

Depression in the chronic pain population can be conceptualized through a variety of models, as described by Banks and Kerns (1996): First, cognitively-oriented models postulate that depressed individuals have a particularly negative style of interpreting life events (Beck, 1967; Beck, 1976). Such individuals become depressed when this thought pattern is applied to their chronic pain problem. Second, and more balanced between

cognitions and behaviors, the learned helplessness model (Seligman, 1975) and its derivatives (e.g., reformulated learned helplessness model and learned hopelessness; Abramson et al., 1978) suggest that individuals make internal, stable, and global attributions about the cause of their pain. For example, the patient blames himself or herself for being in pain and believes that there is nothing that he or she can do about it. Third, behaviorally-oriented theories suggest that the problem is due to a disruption of the reinforcement system (Lewinsohn, 1974). Examples include (Fordyce, 1976): (1) Positive reinforcement may be less available or frequent, such as when an individual is unable to participate in activities that were previously enjoyable; (2) Activities that were previously enjoyable may now be less reinforcing, because they occur in the presence of pain; and (3) The presence of pain may make previously enjoyable events punishing, as the event is now accompanied by an aversive event. The potential exists for one or all of these theories to be primary issues in the relationship between depression and disability.

The difficulty in diagnosing depression in the chronic back pain population has been revealed in assessment. Many have questioned the ability of depression assessments to discriminate depressed from nondepressed chronic back pain patients (Williams & Richardson, 1993; Turk & Okifuji, 1994; Geisser, Roth, & Robinson, 1997; Estlander, Takala, & Verkasalo, 1995). Some suggest that self-report instruments overestimate depression in the chronic back pain population (Williams & Richardson, 1993). Others disagree, indicating that both the Center for Epidemiological Studies Depression Scale (CES-D) and Beck Depression Inventory (BDI) have good predictive validity of depression and simply need higher clinical cut-off scores to account for the presence of more somatic

symptoms in pain patients (Turk & Okifuji, 1994; Geisser et al., 1997; Geisser, Haig, & Theisen, 2000; Harris & D'Eon, 2008).

As a result of the difficulty in diagnosing depression, prevalence estimates vary widely. For example, depressive symptoms, including Major Depressive Disorder, are estimated to be present in 30%-54% of chronic pain patients (Banks & Kerns, 1996). Considering the diagnostic issues described above and the estimate that 50-80% of medical patients experience the somatic-vegetative symptoms of depression, one must consider any prevalence rates of depressive disorders simply as estimates (Doan & Wadden, 1989; Wesley, Gatchel, Polatin, Kinney, & Mayer, 1991).

Despite the definitional and diagnostic issues, the chronic pain literature includes numerous studies that explore the relationship of depression and chronic pain. More symptoms of depression have been associated with worse outcomes in chronic pain patients across studies in the chronic pain population (Geisser et al., 1997), but these findings are independent of the direction of the relationship between depression and pain: Depression is correlated with higher rates of self-reported and functional disability (Alschuler, Theisen-Goodvich, Haig, & Geisser, 2009), for example. For patients, the harsh reality is that depression in chronic pain is most likely a circular relationship, as the studies summarized below indicate that individuals who are depressed suffer from worse or prolonged pain and individuals who suffer from chronic pain are likely to become depressed.

The circularity of the relationship between depression and chronic pain is suggested by two bodies of research. One body of research suggests that depressed patients have a poor response to chronic pain; the other, that pain patients have reason to be depressed. Providing evidence that depressed patients have a poor response to chronic pain are the studies

summarized below. Individuals who are depressed engage in more pain behaviors than patients who are not depressed (Doan & Wadden, 1989). Similarly, patients who are more depressed self-report more pain and less tolerance for pain (Tang, Salkovskis, Hodges, Wright, Hanna, & Hester, 2008). Poor motivation, another symptom of depression, may result in further reduction of activity (Geisser et al., 2003). Cognitively, depressed patients are more likely to make negative assertions about their levels of disability (Geisser, Roth, Theisen, Robinson, & Riley, 2000). The influence of these negative assertions on behaviors is evident in the approach that depressed patients take toward physical activities: depressed patients are more likely to report an inability to engage in daily activities, potentially indicating a lowered self-efficacy or motivation toward engaging in physical activity (Doan & Wadden, 1989). Some have suggested that it is the somatic symptoms of depression, as identified in the last seven questions of the Beck Depression Inventory - II, that cause a disturbance in physical functioning, even after controlling for pain levels (Holzberg, Robinson, Geisser, & Gremillion, 1996).

In the opposite direction, providing evidence that chronic pain patients have reason to be depressed, are the studies that follow. Depression in the context of chronic pain may originate in the wide variety of negative events that accompany chronic pain, as described earlier in this section in reference to Banks and Kerns' (1996) summary of depression in chronic pain patients. Examples included decreased reinforcement due to the engagement in fewer pleasurable events or the perceived punishment of having pain accompany activity. One might also suggest that an individual constantly experiencing pain could easily develop a set of negative thoughts about the presence of pain. These negative thoughts may affect more than simply attitudes about pain, expanding to encompass aspects of the patient's life

that are influenced by the presence of pain, such as activities in which the individual can no longer engage. Thus, these cognitions can influence broad aspects of the patient's life. A circular relationship might develop: a depressed individual may find it more difficult to cope with chronic pain, resulting in a worsening of the pain symptoms.

In summary, despite the overlap in symptoms between depression and chronic pain, a positive relationship between their symptoms has been identified. This highlights depressive symptoms as an important target for intervention in the chronic pain population (Geisser et al., 1997; Sullivan, Adams, Tripp, & Stanish, 2008), and also explains the relative difficulty in treating depression in pain patients compared to non-pain patients (Kroenke, Shen, Oxman, Williams, & Dietrich, 2008). However, the directionality of the relationship of depression and chronic pain remains unclear – for now, they can only be considered as correlates. Further research on depression should identify links between elements of depression and elements of the chronic pain experience, such as disability, which may lead to better interventions for chronic back pain patients.

Catastrophizing. Pain catastrophizing describes a cognitive attributional style that can have toxic influences on patient functioning. This maladaptive coping strategy includes three dimensions: rumination about pain, magnification, and helplessness, as indicated by factor analysis of the commonly used Pain Catastrophizing Scale (PCS; Sullivan, Bishop, & Pivik, 1995). Empirical studies have demonstrated that pain catastrophizing has a significant impact on the experience of chronic pain (Geisser, Robinson, Keefe, & Weiner, 1994; Keefe et al., 1987; Keefe, Brown, Wallston, & Caldwell, 1989; Woby, Roach, Urmston, & Watson, 2007), and it is one of the few dimensions of pain coping that have shown strong and consistent relationships to the experience of pain (Geisser, Robinson, & Riley, 1999; Jensen,

Turner, Romano, & Karoly, 1991; Keefe, Rumble, Scipio, Giordano, & Perri, 2004).

Research on catastrophizing has explored three broad domains: relationship of

catastrophizing to depression, role of catastrophizing in the experience of chronic pain, and

role of catastrophizing in the transition from acute to chronic pain.

Some scientists have questioned the independence of catastrophizing from

depression, as the set of catastrophic thoughts could be conceptualized as consistent with the

cognitive patterns common to depressed individuals. One of the original studies on

catastrophizing (Sullivan & D'Eon, 1990) suggested that catastrophizing is characterized by

a negative outlook on future outcomes and that clinical psychologists view catastrophizing as

a set of symptoms related to depression. Subsequent studies have attempted to clarify the

catastrophizing construct by examining the catastrophizing-chronic pain relationships while

controlling for depressive symptoms. These studies indicate that catastrophizing is

significantly correlated with pain and pain-related disability independent of the influence of

depression (Geisser & Roth, 1998; Geisser et al., 1994; Keefe, Brown, Wallston, & Caldwell,

1989; Geisser et al., 2003; Sullivan, Standish, Waite, Sullivan, & Tripp, 1998; Turner,

Jensen, & Romano, 2000). These studies put a unique value on the set of catastrophic

thoughts that one has about his or her pain problem, independent of the presence of a positive

or negative affect.

Catastrophizing influences the behavior of chronic pain patients in several ways. The

most significant effect of catastrophizing on chronic pain is that pain patients make

appraisals about their pain that may lead them to be hypervigilant towards painful or

threatening sensations and fearful of experiencing future painful sensations. Hence,

hypervigilance, an increased attentional focus on painful stimuli, makes individuals more

aware of the presence of painful stimuli and causes them to attach more threat of harm to non-painful stimuli due to greater pain-related fear (Vlaeyen, Kole-Snijders, Rotteveel, Ruesink, & Huets, 1995; Crombez, Eccleston, Baeyens, & Eelen, 1998; Rollman, 2009). Further, catastrophizing has a stronger relationship to pain intensity than to disability (Woby, Roach, Urmston, & Watson, 2007), indicating that catastrophizing may alter one's perception of the severity of his or her pain, which in turn influences behavioral decisions that ultimately cause a disabled lifestyle. This role of catastrophizing as a precursor to pain-related fear is reviewed extensively in the Anxiety and Fear subsection below.

The effect of catastrophizing also extends to recuperation from the onset of pain. For example, catastrophizing was identified as a mediator in patient outcome when multiple treatment approaches for chronic pain were compared (Smeets, Vlaeyen, Kester & Knottnerus, 2006). Furthermore, catastrophizing was shown to be related to protective pain behaviors, such as guarding, holding, touching, or rubbing, that are commonly seen in disabled patients (Thibault, Loisel, Durand, Catchlove, & Sullivan, 2008). These studies implicate catastrophizing as a particularly important target for all chronic back pain treatments.

Extending beyond the literature that describes the relationship of catastrophizing and chronic pain, a small segment of the literature has focused on the role of catastrophizing in the *development* of chronic low back pain. Catastrophizing has been identified as a major predictor of the development of chronic back pain among acute low back pain patients, with 47% of the variance accounted for by catastrophizing (Burton, Tillotson, Main, & Hollis, 1995). Further, pain catastrophizing has been identified as the best predictor of the development of back pain one year following pain-free baseline (Linton, 2005). Among low

back pain sufferers in the general population, pain catastrophizing significantly predicted pain-related fear 6 months later, even after controlling for pain-related fear at baseline (Leeuw et al., 2007). Considering the predictive value of catastrophizing, clinicians might be able to identify at-risk acute pain patients through their tendency for catastrophizing. In fact, patients who use the ineffective coping strategy of bed rest for acute pain are commonly high catastrophizers (Verbunt, Sieben, Vlaeyen, Portegijs, & Knottnerus, 2008).

When the relative effectiveness of coping strategies other than catastrophizing has been explored, catastrophizing has been identified as not the only coping strategy that is maladaptive or ineffective: individuals who take passive approaches (e.g., praying and hoping, Gatchel, 1999) also have poor outcomes. Individuals who attempt to ignore their pain or distract themselves from their pain do not see improvement in adjusting to chronic pain (Gatchel, 1999). A better alternative is an active approach, in which individuals engage in exercise and activity (Jensen et al., 1991).

As illuminated in this section, the maladaptive nature of catastrophizing can be a significant contributor to pain-related anxiety and fear-avoidance behaviors, thus making catastrophizing a significant contributor to disability in the chronic back pain population. The next section describes this fear-avoidance model in detail.

Anxiety and fear. For most patients, experiencing pain is an aversive experience. As a result, the prospect of experiencing pain in the future stimulates fear and anxiety (Leeuw, Goossens, Linton, Crombez, Boersma, & Vlaeyen, 2007). Anxiety may be exemplified by a person's engagement in avoidance behaviors that prevent an anxiety-provoking event from occurring. People who are anxious often demonstrate a heightened awareness or hypervigilance to such stimuli. Fear is a more specific form of anxiety,

directed towards a specific threat. In the case of pain, fear is oriented toward the behaviors that are associated with pain. A common response to the fear of pain is the engagement in escape behaviors that allow the individual to terminate the painful sensation. Exemplifying this point, a recent study used such an explanation of fear to explain individual differences in performance on clinical lifting tasks (Sullivan, Thibault, Andrikonyte, Butler, & Catchlove, 2009)

The effects of fear and anxiety as related to pain is studied as kinesiophobia, the fear of movement or re-injury. Vlaeyen and colleagues (e.g., Vlaeyen & Linton, 2000) have found fear of movement and re-injury are better predictors of disability than medical predictors, pain, or even catastrophizing (Vlaeyen et al., 1995). Their model hypothesizes that patients who suffer from pain engage in certain responses to alleviate painful symptoms that are present and also avoid certain activities in hopes of preventing future pain. The result is often a significant decrease in activity, leading to a disabled lifestyle. As discussed in the following subsection, the dominant fear-avoidance models extend beyond fear and anxiety, also incorporating the other aspects of the cognitive-behavioral conceptualization, such as depression and catastrophizing.

Fear-avoidance model: a comprehensive cognitive-behavioral model. The fear-avoidance model postulates that disability in the chronic pain population results from avoiding activities that could lead to the presentation of pain, an aversive stimulus. The original fear-avoidance model, proposed by Lethem and colleagues (1983), has now become one of the prominent explanations of inactivity in chronic low back pain patients.

The current research on the fear-avoidance model originates in a series of studies by Vlaeyen and colleagues (Vlaeyen & Linton, 2000; Vlaeyen et al., 1995; Vlaeyen, Kole-

Snijders, Boeren, & van Eek, 1995; Verbunt, Seelen, Vlaeyen, van der Heijden, &

Knottnerus, 2003a; Verbunt et al., 2003; Swinkels-Meewisse, Roelofs, Verbeek, Oostendorp,

& Vlaeyen, 2003; Crombez, Vlaeyen, Heuts, & Lysens, 1999; Leeuw et al., 2007a, Leeuw et

al., 2007b). These investigators have been pioneers in expanding on the theories of

avoidance learning, fear of pain, and fear of movement or re-injury, by developing the

modern fear avoidance model (see Figure 1). The findings by Vlaeyen and colleagues have

been supported and expanded upon by other researchers, such as Asmundson (2004) and

Norton and Asmundson (2003).
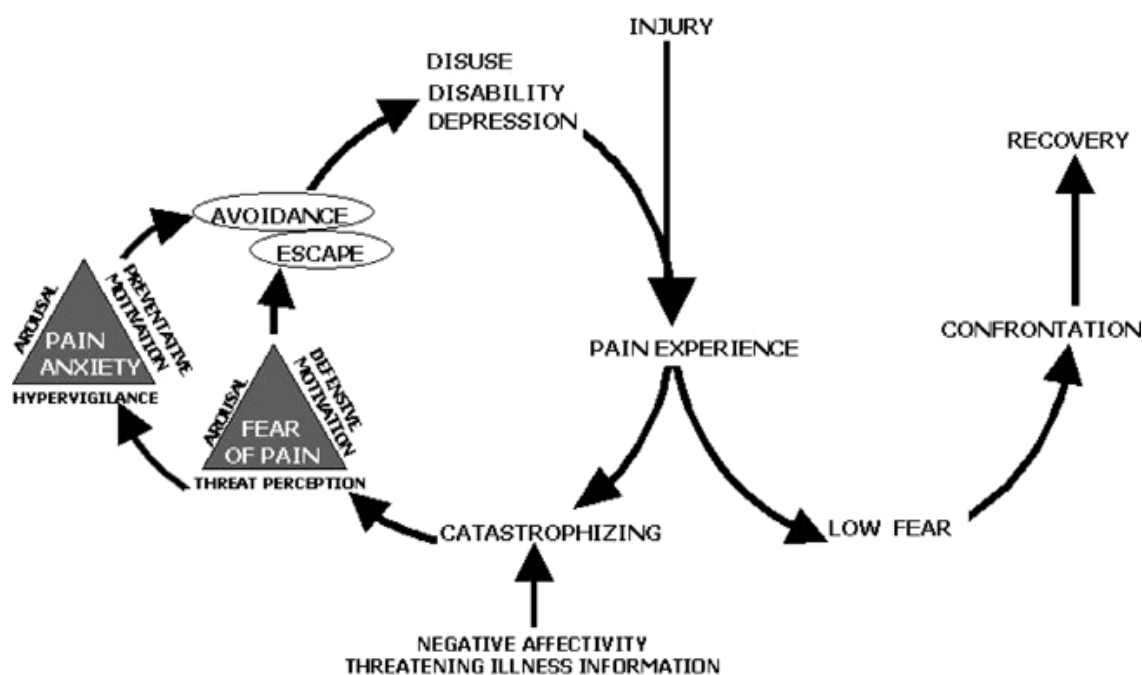
Figure 1. The fear-avoidance model of chronic pain. Summarizing Vlaeyen and Linton

(2000) and the fear-anxiety-avoidance model of Asmundson et al. (2004). (Leeuw et al.,

2007)

The fear-avoidance model depicted in Figure 1 suggests that following the experience

of pain, individuals appraise pain in either an adaptive or maladaptive manner, thus

dichotomizing those who become chronic pain sufferers from those who do not. Persons likely to become chronic pain patients make negative appraisals and engage in catastrophizing, the set of negative cognitions about the pain problem and negative expectations about future outcomes. As described in the Catastrophizing subsection above, catastrophizers suffer from increased pain intensity, pain-related disability, and psychological distress (Severijns, Vlaeyen, van den Hout, & Weber, 2001; Jensen, Turner, & Romano, 2007). Most important to the fear-avoidance model, catastrophizers are more likely to fear that certain behaviors will cause pain or injury (Geisser et al., 2003; Sullivan & D'Eon, 1990; Geisser , Robinson, Keefe, & Weiner, 1994; Boothby et al., 1999).

In response to the fear instigated by excessive catastrophizing and in an attempt to control the occurrence of pain in the future, patients engage in escape and avoidance behaviors and become hypervigilant to pain (Vlaeyen & Linton, 2000; Crombez, van Damme, & Eccleston, 2005; Crombez, Eccleston, De Vlieger, Van Damme, & De Clercq, 2008). As depicted in Figure 1, some have suggested that two factors are influential at that period (Leeuw et al., 2007a; Asumndson, Norton, & Vlaeyen, 2004): First, in the presence of pain, a patient will seek to escape from the sensation, thus exemplifying fear of pain. Second, the patient is likely to become anxious about experiencing pain in the future, resulting in avoidance behaviors. In both cases, whether seeking to stop pain or avoid pain in the future, the patient is likely to significantly change his or her behavioral pattern.

The escape and avoidance behaviors and resulting change in activity can lead to a detrimental trio of symptoms: disability, disuse, and depression. As a result, one could postulate that engagement in avoidance behaviors is the most important variable in determining whether one will become disabled (Geisser, Haig, & Theisen, 2000).

Disability is likely a function of the reduction in daily activity due to the escape and avoidance behaviors, as the individual fails to engage in important activities. The relationship of fear-avoidance behavior with disability has been established in numerous studies (e.g., Leeuw et al., in press; Turner, Jensen, & Romano, 2000).

Disuse describes the deterioration of aerobic and muscular physical fitness that results from inactivity (Leeuw et al., 2007). Typically, disuse is considered in a pure physiological form, called deconditioning, or as a *disuse syndrome*, which is the combined effect of disuse on physiological and psychological functioning (Verbunt et al., 2003a). The effects of disuse on future pain and functioning may be significant and are discussed later in this section.

Depression was described previously in this paper as a correlate of chronic pain. In the fear-avoidance model, depression may result from thinking negatively about the pain problem (Geisser et al., 1994; Holzberg, Robinson, & Geisser, 1993; Holzberg, Robinson, Geisser, & Gremillion, 1996; Williams, Robinson, & Geisser, 1994), having fewer opportunities for reinforcement due to engaging in fewer pleasurable activities (disability; Robinson & Riley, 1999), and experiencing repeated punishment by experiencing pain (learned hopelessness; Robinson & Riley, 1999; Banks & Kerns, 1996).

The fear-avoidance model is circular, as the factors that result from escape and avoidance behaviors are also suggested to increase the likelihood of more painful experiences. For example, inactivity may be considered as one precursor of future painful experiences. Exercise-based treatments, which directly oppose the inactivity that plagues many chronic pain patients, have been successful in reducing pain, thus yielding numerous interpretations of the physical activity – pain relationship (van der Velde & Mierau, 2000). One resulting hypothesis is that not engaging in activities and not using muscles results in a

loss of fitness, called deconditioning, though this view has only received moderate support (Wittink, Michel, Wagner, Sukiennik, & Rogers, 2000; Wittink, Michel, Sukiennik, Gascon, & Rogers, 2002; Hurri et al., 1991; Verbunt, et al., 2003a, 2003b; Bousema et al., 2007). If deconditioning were the case, engaging in activity in treatment would serve to restore an appropriate level of physical conditioning. Others have hypothesized that the problem is that inactivity results in musculoskeletal abnormalities and limited flexibility (Geisser, Haig, Wallbom, & Wiggert, 2004), suggesting that active treatments are beneficial in their ability to rectify these physical problems. Inactivity may contribute to disability in other ways as well: It may result in an absence of exercise-induced analgesia, which is the release of endorphins that results from physical activity and naturally reduce pain. Exercise-induced analgesia has been reported in response to a variety of types of experimental pain, as well as in chronic pain patients and representative animal samples (Hoffman, Shepanski, MacKenzie, & Clifford, 2005; Hoffman et al., 2004; Koltyn, 2000; Geisser et al., 2008c). However, the duration or intensity of activity necessary for the analgesic effect has not been established. An exemplary study identified 30 minutes at 75% of VO2 max as the threshold for exercise induced analgesia (Hoffman et al., 2004). That level of exercise is equivalent to a moderate workout for an aerobically fit individual or 30 minutes of low-level activity for a less fit individual, such as an inactive chronic pain patient. Finally, active treatments may alleviate psychological correlates, such as helping the individual to access reinforcers through a return to normal daily activities (alleviating depression), or exposure to activities that were feared, thus reducing avoidance behaviors related to anxiety (Smeets et al., 2006b; van Tulder, Malmivaara, Esmail, & Koes, 2000; Leeuw, Goossens, van Breukelen, de Jong, Heuts, et al., 2008; Woods & Asmundson, 2008). (The role of depression in chronic pain

patients has been reviewed in detail in the Depression section above. Its effect on future pain is summarized below.) Despite the undiscovered mechanism influencing the relationship between inactivity and pain, the literature clearly identifies inactivity as a maintaining factor of pain. Interestingly, chronic low back pain is most severe at the ends of the physical activity spectrum, either with high or low levels of activity (Heneweer, Vanhees, & Picavet, 2009). This further explains the relationship recognized in the fear-avoidance model, as patients who experience injury may have participated in a high level of activity prior to the onset of pain and transition to a low level of activity, thus bypassing the optimal moderate level of activity.

The role of depression and other psychosocial factors in the persistence of pain is clearer. For example, negative emotions are correlated with increased pain intensity and, some believe, sensitivity to painful stimuli (Melzack & Wall, 1965; Robinson & Riley, 1999). Additionally, pain-related fear and the resulting escape and avoidance responses are a better predictor of disability than pain intensity (Crombez, Vlaeyen, Heuts, & Lysens, 1999). Finally, some have identified the interaction of psychosocial factors with chronic pain through various patterns of elevation in the Hypochondriasis (scale 1), Depression (scale 2), and Hysteria (scale 3) scales on the MMPI-2, thus suggesting that individuals with heightened neurotic and anxious responses to pain are more likely to continue to experience pain (Gatchel, 1996). In all of the situations above, a circular pattern presents itself: The same individual who has an increase in pain due to negative emotions, heightened anxiety, and persistent worry may also suffer from more negative emotions, worsened anxiety, and increased worry due to the increase in or persistence of pain.

In sum, the fear-avoidance model is credited with explaining the variance in persistence of poor physical functioning that is not simply predicted by pain perception (Al-Obaidi, Nelson, Al-Awadhi, & Al-Shuwaie, 2000; Gheldof et al., 2006). As a whole, it describes a particularly maladaptive series of behaviors and outcomes that describe the chronic pain experience. The model can be applied across the stages of the pain experience, affecting both the development and maintenance of chronic pain (Leeuw et al., 2007; Boersma & Linton, 2006), suggesting numerous opportunities for interrupting this vicious cycle.

Future research on cognitive-behavioral factors. Future basic research on cognitive-behavioral elements of the chronic pain experience has the potential to drive the development of future psychological interventions for the chronic pain population. Such research could benefit the chronic pain population by clarifying the relative value of the various elements within the cognitive-behavioral model as well as assessing the relative strength of targeting cognitive-behavioral factors for intervention relative to targeting social factors or pain intensity.

Social/Environmental Influences

The pain and cognitive-behavioral explanations of chronic back pain are focused on factors that are internal to the patient in pain. A patient can feel painful stimuli or have certain cognitions independent of outside influences. However, discounting external influences would be a mistake, considering that we live in an environment with high levels of human and environmental interaction. The present section reviews the interaction of social

and environmental influences with chronic pain and the role that such factors play in the reinforcement of the pain behaviors that comprise disability in the pain population.

Reinforcement of pain behaviors vs. absence of well behaviors. To understand the role of social factors in the reinforcement of pain behaviors, one must first understand what is being reinforced. As defined by Fordyce (1976), the focus of the behavioral analysis of chronic pain is on pain behaviors. This conceptualization describes pain behaviors and well behaviors as incompatible behaviors, meaning that one cannot occur in the presence of the other. For example, one cannot seek pain medications (pain behavior) and not seek medications (well behavior) simultaneously.

Thus, operant reinforcement can have a similar effect by either reinforcing pain behaviors or reinforcing the avoidance of well behaviors. The reinforcement of either variable increases the behaviors related to a more disabled lifestyle.

Sources of operant reinforcement. Social factors influence pain through direct positive reinforcement of pain behaviors (Fordyce, 1976; Flor, Kerns, & Turk, 1987; Turk, 1996). Such reinforcement is defined by the presentation of a reward in direct response to a behavior, with the purpose of increasing that behavior. For chronic back pain patients, this reinforcement commonly comes through the attention that one receives from family members. This pattern can be identified as far back as childhood: When a child is in pain, he or she expresses pain behaviors (e.g., crying, screaming) and receives attention from a parent. An association is made between the expression of pain behaviors and the pleasant response of receiving attention (Fordyce, 1976). Understanding that humans are often guided by rule-governed behavior, it is clear that patterns of behavior developed in childhood could inspire rule-governed behavior for chronic pain, contributing to future pain-related behavior.

This pattern of attention-seeking behavior may continue into adulthood. When an adult patient suffers from chronic back pain, a common source of direct positive reinforcement is the patient's spouse or partner. Through frequent daily interactions, the spouse influences the presence of pain behaviors by the way he or she responds to the patient's complaints of discomfort (Flor et al., 1987; Turk, 1996; Turk & Flor, 1999). Spousal responses are described in the widely used Multidimensional Pain Inventory (MPI; Kerns, Turk, & Rudy, 1985) as punishing (e.g., irritates, frustrates, ignores), solicitous (e.g., gives medications, takes over chores, asks how to help), or distracting (e.g., helps take mind off pain). Each type of response influences the patient's pain differently (Kerns, Turk, & Rudy, 1985; Romano et al., 1995). Chronic pain patients who have "solicitous" spouses have been shown to have more intense pain, disability, activity limitations, pain behaviors, and psychological distress, and lower pain thresholds and tolerance levels compared to those without solicitous spouses (Turk, 1996; Leonard, Cano, & Johansen, 2006; Cano, Gillis, Heinz, Geisser, & Foran, 2004; Cano, Weisberg, & Gallagher, 2000; Flor, Breitenstein, Birbaumer, & Furst, 1995; McCracken, 2005). Application of operant principles indicates that a solicitous spouse is reinforcing the presence of pain behaviors by paying attention to the patient, making it desirable to the patient to display pain behaviors in the future. This also explains the gradual worsening of pain behaviors in some patients. If the spouse gradually ignores the patients' pain behaviors, the patient will exemplify an extinction burst by engaging in more and more severe pain behaviors to gain the attention and response of the spouse. This process does not necessarily have to be intentional, as patients and spouses may not recognize the implications of their interaction (Fordyce, 1976).

"Punishing" responses have a similar effect to "solicitous" responses, in that they also maintain or increase pain behaviors. Responding in a punishing manner has been theorized to lead the pain sufferer attempts to prove to the significant other that he or she truly is suffering (McCracken, 2005). Alternatively, "distraction" produces a more positive result in patient disability. When distracted appropriately from their pain problem, patients engage in meaningful activities that were previously avoided (McCracken, 2005).

The three types of responses performed by significant others that were defined in the initial validation of the MPI have been scrutinized repeatedly in the literature. Although follow-up studies have identified the initial factor structure as the most accurate interpretation of the MPI (Riley, Zawacki, Robinson, & Geisser, 1999), others suggest changes. Some believe that patient behavior is more closely related to simply the responsiveness of spouses, independent of the type of response (Williamson et al., 1997). Others have suggested that certain scales produce similar results: In one case, solicitousness was suggested to operate similarly to punishment (McCracken, 2005), while others suggested that solicitousness and distraction did not significantly differ (Bernstein, Jaremko, & Hinkley, 1995). Despite the differences in interpretation of the MPI structure, all of the studies references above support social factors as being influential on pain patient behaviors.

The frequency of contact between chronic pain patients and their spouses make spousal behavior one of the most researched sources of direct reinforcement. However, anybody can be a source of reinforcement, as long as their response to the pain behaviors is meaningful to the patient. For example, physicians are another common source of reinforcement, as they are typically more responsive when pain behaviors are present

(Fordyce, 1976). Physicians have a unique ability to reinforce pain behaviors through medications, which physicians are more likely to prescribe when a patient is in pain.

Why spouses, physicians, and others respond to pain sufferers. Spouses and physicians engage in solicitous responses because of the reinforcement value to themselves, as well. Fordyce (1976) suggests that spouses may be reinforced by feeling wanted or useful when they respond to pain behaviors. Physicians and nurses commonly use the expression of pain (e.g., grimacing) as an indicator of level of pain and are reinforced by reducing a patient's pain and seeing a decrease in such pain behaviors (Hirsh, George, & Robinson, 2009). Thus, physicians and spouses, among others, behave in a way that is reinforcing to them, as well. Such individuals do not behave arbitrarily: they are more likely to engage in behavior that is reinforced.

More recently, empathy has been identified as an additional reason that observers (i.e., any person observing a patient in pain) react as they do to patients in pain. Goubert and colleagues (2005) summarized the literature on empathy by describing the cues that observers utilize in deciding to react, including facial expressions and similarities to prior personal experiences. Simply put, pain naturally recruits an altruistic response from others (Hadjistavropoulous, Craig, & Fuchs-Lacelle, 2004). However, a risk exists that inaccurate levels of empathy may increase pain behavior (Hadjistavropoulous, Craig, & Fuchs-Lacelle, 2004; Goubert et al., 2005). When observers fail to identify the patient as being in pain, the patient may increase pain behaviors until they get the solicitous, empathic result they were expecting. This is akin to what was previously described in solicitous spouse behavior. Observers may also overreact to pain, which sends an inadvertent signal to the individual regarding their level of pain. If the pain sufferer did not find the stimulus painful, but the

observer reacted otherwise, the patient may determine that he or she is actually in more pain than originally realized.

Environmental sources of operant reinforcement. Despite the general focus on attention as a primary social reinforcer of pain behaviors, other social factors may also reinforce continued engagement in pain behaviors. It may be more valuable for a pain patient to continue to exhibit pain behaviors in an effort to avoid returning to a stressful or unsatisfactory employment environment or to increase the chances of winning a lawsuit to gain disability compensation (Geisser et al., 2003).

Additionally, some patients view the return to work through a risk-reward lens (Patel, Greasley, & Watson, 2007): Returning to work has the potential reward of being more lucrative than receiving disability payments. However, many patients are so concerned about the uncertainty of their pain condition, that they fear returning to work, being unable to fulfill their duties, and getting fired, thus losing all benefits. Thus, patients are more likely to take the safe route of continuing on disability payments.

Through both explanations, the patient is reinforced for not engaging in well behaviors, suggesting that it is beneficial to remain inactive and disabled in an effort to maintain disability status.

Summary. Social factors related to chronic pain may provide an additional target for treatments in chronic pain, beyond pain and cognitive-behavioral factors. Future research could improve treatment approaches by continuing to identify sources of reinforcement and the strength of social reinforcement relative to the other elements of the chronic pain experience, such as cognitive-behavioral factors and pain intensity.

Summary of the Literature on Chronic Back Pain

As exemplified above, the literature on chronic back pain covers three broad areas: the experience of pain, cognitive-behavioral correlates of the experience of pain, and social and environmental reinforcers of being in pain. The studies have been groundbreaking and insightful, leading to new directions in both the research and treatment of chronic back pain. At the same time, the literature reveals a somewhat disjointed set of research, with each study exploring a small niche within the chronic back pain field. Additionally, due to the multiple forms of assessment available, studies focusing on disability come to varying conclusions in part depending on the disability assessment utilized in that study.

Thus, these contradictions in the literature call for a new set of research that will enhance the findings presented thus far. Future studies would benefit from taking two primary directions: First, the studies should take a more comprehensive approach to evaluating the factors related to chronic back pain disability, spanning across the three domains commonly researched in chronic pain. Second, the studies should utilize disability assessments that are applicable to the distressing aspects of disability (e.g., changes in the way one must lead his or her life) and are comprehensive (e.g., assess disability through multiple methods).

Purpose of the Present Study

The present study sought to extend what is known about the relationship between psychosocial factors and disability. Two primary mechanisms were employed.

First, this study employed computerized real-time ambulatory monitoring to assess physical activity. Previously, many studies of disability have focused on functioning or

activity as a core measure, indicating that functioning is a particularly important part of the conceptualization of disability (Vasudevan, 1992). Unfortunately, these results are limited by self-report biases that are problematic when using self-report measures (Kop et al., 2005). This should be particularly apparent when considering that, for example, a depressed patient is likely to think negatively about his or her condition and, therefore, may respond more negatively to a self-report measure of disability regardless of actual levels of disability. In other words, the patient may be purely suffering from depression about their condition, not an inability to function. Therefore, it is important to differentiate measures of activity from cognitive, behavioral or social influences.

The use of objective measures of activity improves measurement and reduces the biases that may result from retrospective self-report (Kop et al., 2005). Recent studies have validated the use of ambulatory monitoring devices as one such form of objective measurement (Kop et al., 2005; Bussman, van de Laar, Neeleman, & Stam, 1998). Additionally, these devices are generally easy to use and measure activities of daily living (Spenkelink, Hutten, Hermens, & Greitemann, 2002). Although the use of ambulatory monitoring devices has been validated as a reliable way to measure physical activity in the chronic pain population, this technology has not been used to extensively explore the factors that precede, accompany, or result from disability in the chronic pain population. Two studies have used accelerometers to assess activity in chronic pain patients: One study compared activity in "distressed" patients to activity in "non-distressed" patients (Ryan, Gray, Newton, & Granat, 2009), while another measured activity in chronic pain patients compared to healthy controls (Spenkelink et al., 2002; van Weering, Vollenbroek-Hutten, & Hermens, 2009). A recent review of the literature established accelerometers as the best

method of measuring physical activity in chronic pain patients (Verbunt, Huijnen, & Koke, 2009).

Two studies in the literature utilize ambulatory monitoring devices to assess physical activity in chronic low back pain patients (Liszka-Hackzell & Martin, 2004; Van Weering et al., 2009). Liszka-Hackzell and Martin (2004) assessed both chronic and acute low back pain patients to explore the relationship of their reported pain levels and physical activity. The real-time physical activity data collected with an accelerometer were compared to subjective pain ratings. A similar but more extensive use of the accelerometer and its functions was used in the present study. Van Weering et al. (2009) compared activity patterns of chronic low back pain patients and healthy controls. Their findings suggest that overall activity patterns between the two groups are similar, but the distribution of activity throughout the day differs significantly between the two groups.

The second unique aspect of the current study is that, unlike prior research, three primary areas of focus in the chronic pain population were assessed simultaneously: pain, cognitive-behavioral factors (e.g., depression, anxiety), and social factors (e.g., spousal solicitousness). In combination with use of real-time monitoring of activity, this study allows for the comparison of disability models based on an objective measure of physical activity, rather than perceived disability. A particularly interesting additional benefit of using this method of measurement is that commonly explored elements of the pain-disability relationship can be explored more thoroughly. The real-time nature of the assessment allows for temporal relationships to be explored through comparisons between anticipated pain levels, current pain levels, and amount of activity. Thus, the ebb and flow of pain levels will be respected as the influence of pain will be assessed over time.

Justification and Significance

Back pain is one of the most common problems health care providers treat. Over any 3-month period, approximately 27% of people 18 and over have back pain (National Center for Health Statistics, 2006). Patients with one low back pain incident incur medical costs of $3,718 annually, rising to $4,805 after a second incident, $5,874 after three to five incidents, and $6,888 after six or more episodes (Ritzwoller et al., 2006). Moreover, the patients with the highest number of low back pain incidents were responsible for a significant amount of the total health care costs for this problem. Back pain has frequently been recognized as one of the most costly health problems. Thus, reducing the recurrence of back pain should be targeted in an effort to reduce healthcare costs.

The present study has the potential to improve our understanding of chronic back pain disability, as the methodology allows for the simultaneous assessment of the contribution of three important domains (pain, cognitive-behavioral, and social/operant) to variations in *actual* levels of physical activity among chronic low back pain patients. This is an improvement on previous studies that have either (a) used a self-report measure to assess disability or (b) used the ambulatory monitoring technology to conduct a less comprehensive assessment.

This study makes it possible to determine how chronic back pain disability is uniquely and simultaneously affected by pain intensity, cognitive-behavioral, or social/operant factors. This is clinically relevant, as researchers with the Initiative on Methods, Measurement, and Pain Assessment in Clinical Trials (IMMPACT) have suggested that an important outcome of medical treatment for chronic pain is the patient's improvement

across elements of each of these same domains (Turk, Dworkin, Revicki, Harding, Burke, et

al., 2008). Thus, the present study has the potential to contribute to the effort to improve

health care. The unique information provided about chronic back pain disability could assist

in the development of effective treatments for chronic pain by identifying specific targets for

these treatments. Ultimately, this could serve to improve patient outcomes and reduce health

care costs.

Research Questions, Hypotheses, and Specific Aims

Research question 1:   Which contributes to more of the variance in chronic back pain

disability: pain or the anticipation of pain?

Hypothesis 1:   It was hypothesized that the anticipation of pain would contribute to

more of the variance in chronic back pain disability than current pain.

Rationale: The literature on anticipation of pain suggests a strong relationship

with fear of pain and fear of movement, variables previously found to

be associated with disability. The literature on current pain is more

contradictory regarding the association between current pain and

disability.

Research question 2:   Which of the three primary models of chronic back pain disability –

pain, cognitive-behavioral, and social/operant – accounts for the most

variance in chronic back pain disability?

Hypothesis 2:   It was hypothesized that social factors would account for more of the

variance in chronic back pain disability than the cognitive-behavioral

or pain factors.

Rationale: The literature supports cognitive-behavioral and social factors as the

strongest categories of predictors of disability. Due to between patient

inconsistencies in the application of pain ratings, it seems unlikely that

pain variables would be predictive of disability. Although the largest

body of literature has explored cognitive-behavioral variables,

particularly in terms of the fear-avoidance model, the empirical

support for social factors is also very strong. Additionally, the mechanism for social interactions to influence disability is through interactions surrounding physical activity, whereas cognitive-behavioral variables impact how one thinks about his or her situation (e.g., their perception of disability). Thus, support exists for variables representing the social model to be the strongest predictor of physical activity.

METHOD

Participants

A total of 20 patients with chronic low back pain (≥ 3 months of chronic pain) participated in this study. Inclusion criteria were age between 18 and 60 years of age; presence of back pain for 3 or more months; and ability to ambulate without an assistive device. Exclusion criteria were presence of other conditions that interfere with gait or are significantly disabling, such as stroke, peripheral neuropathy, Parkinson's Disease, Multiple Sclerosis, or Lupus; presence of a physical disability that prohibits physical exercise; diagnosis of dementia or psychotic features, as determined by the psychologist during evaluation; and currently receiving Occupational Therapy or Physical Therapy. (Criteria are included as part of the Psychologist Screening Form, Appendix A.) Patient recruitment flow is depicted below in Figure 2.
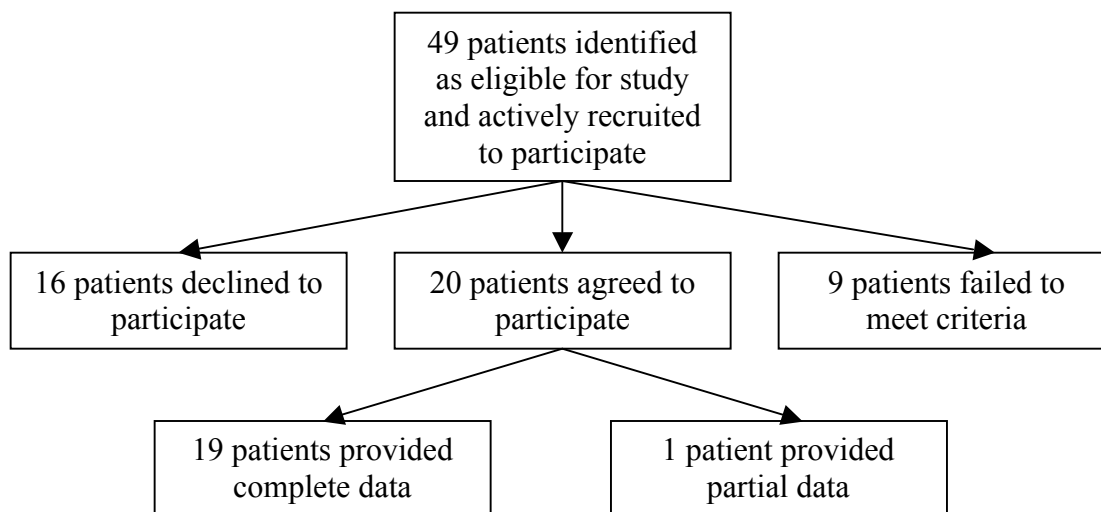
Figure 2. Patient recruitment flow.

Due to simultaneous data collection related to research questions beyond the scope of the study described herein, participants were primarily recruited from the University of Michigan Spine Program's Multidisciplinary Spine Treatment (MST) program. However, participation was also open to non-MST patients undergoing treatment at the Spine Program, provided they met the inclusion criteria. The primary difference in these two groups of patients was the treatment course chosen by the patient's physician, as opposed to individual differences in patient characteristics.

Participants had a mean age of 46.1 years (range 23 to 58, SD = 9.35), and were almost evenly split between females (n = 9) and males (n = 11). They primarily identified as white (n = 18), with one participant identifying as African American and one as American Indian. Participants indicated that their low back pain had existed for a mean of 40.75 months (range 8 to 216, SD = 51.71). Most indicated they were not working due to their pain problem (n = 13), while the remainder were working full-time (n = 4), part-time (n = 4), or retired (n = 1). Nine participants were currently receiving disability payments, and two were involved in ongoing litigation regarding their pain problem. Participants had completed a mean of 13.7 years of education (range 9 to 18, SD = 2.60).

Measures

The measures detailed below reflect two different time-frames: A majority of the measures were collected as cross-sectional data during a baseline assessment period. The remaining data were collected as repeated-measures data over a five-day period following the baseline assessment.

Baseline assessments. At the beginning of the study, participants were given an assessment battery to gather information on factors that were considered to be stable over a period of time longer than the duration of this study and, thus, only needed to be assessed at one time. The questionnaires revealed information about (1) the patient's background; (2) cognitive-behavioral factors; (3) operant factors; (4) pain sensitivity; (5) perceived disability; and (6) physical ability.

The following questionnaires were used for this assessment:

1. Demographic background

   a. *Demographics questionnaire (Appendix B).* Identified basic demographic information regarding age, sex, dominant hand (necessary for determining arm for Actiwatch), marital status, ethnicity, race, education, employment status, disability status, litigation status, and months in pain.

2. Cognitive-behavioral factors

   The cognitive-behavioral elements of this study were operationalized as depressive symptoms (measured by Center for Epidemiological Studies Depression Scale), pain catastrophizing (measured by Pain Catastrophizing Scale), and pain anxiety (measured by the Tampa Scale for Kinesiophobia). These three variables are conceptually grouped through the fear-avoidance model that was reviewed in the literature review above. Empirically, these three factors have strong relationships, ranging from r = 0.39 to r = 0.69 (all *p* < .01), with the strongest relationships between depression and catastrophizing (Jones et al., 2003; Goubert, Crombez, & Van Damme, 2004; Cook, Brawer, & Vowles, 2006; Geisser, Robinson, & Riley, 1999b; Geisser, Roth, & Theisen, 2000).

a. *Depression: Center for Epidemiological Studies Depression Scale (CES-D; Radloff,*
    1977; Appendix C). The CES-D is a 20-item measure of symptoms of depression.
    Patients rate symptoms on a 0 to 3 scale, in reference to the previous week. A total
    score is tabulated, with higher scores indicating more depressive symptoms. The
    CES-D has been commonly used in the pain literature, with studies demonstrating
    that the CES-D has better sensitivity to change than the Beck Depression Inventory-II
    (Geisser, Roth, & Robinson, 1997).

b. *Catastrophizing: Pain Catastrophizing Scale (PCS; Sullivan et al., 1995; Appendix*
    D). The PCS is a 13-item measure of catastrophizing about pain. Ratings obtained
    relate to three categories: rumination, magnification, and helplessness. Validation of
    the PCS indicated that the instrument is high in internal consistency ($\alpha = 0.87$) and
    test-retest reliability ($\alpha = 0.75$). The factor analysis used for the identification of the
    three catastrophizing categories revealed that the rumination subscale accounted for
    41% of the variance of the total score, magnification accounted for 10%, and
    helplessness for 8%. A high correlation was identified between rumination and
    hopelessness ($r = -.50$), with moderate correlations between rumination and
    magnification ($r = .32$) and helplessness and magnification ($r = -.30$). Of particular
    note, the hopelessness subscale of the PCS was developed based on the
    conceptualization of Rosentiel and Keefe (1983), creators of the Coping Skills
    Questionnaire (CSQ). The CSQ is a measure of many types of coping strategies,
    including the hopelessness aspect of catastrophizing. Five of the six questions on the
    hopelessness subscale of the PCS match the CSQ Catastrophizing subscale. The
    choice to use the PCS maximizes the information attained, allowing for the analysis

of catastrophizing as a multidimensional construct and through any of the three

unique elements represented by the subscales. In addition, using the PCS allows for

analyses that are consistent with the literature on pain catastrophizing, which is based

on either the multidimensional measurement of catastrophizing through the PCS or

simply the hopelessness-oriented CSQ Catastrophizing subscale.

c. *Anxiety: Tampa Scale for Kinesiophobia-11 (TSK-11; Woby, Roach, Urmston, &*

Watson, 2005; Appendix E). The TSK-11 is an 11-item measure of fear of

movement/(re)injury developed through the removal of 4 items from the original

TSK. The four items that were eliminated were reverse-scored items that were found

to have low item-total correlations. Items on the TSK-11 are rated on a 4-point Likert

Scale and can be summed for a total score. Goubert and colleagues (2004) have also

proposed a two-factor model for analyzing TSK scores, dividing answers into harm

and fear-avoidance subscales. The TSK-11 has both high internal consistency ($\alpha =$

0.76) and split-half reliability ($\alpha = 0.81$).

3. Operant factors

Operant factors are represented by patients' spouses' responses to their pain. The

three primary response types – solicitous, distracting, punishing – are assessed on the West

Haven-Yale Multidimensional Pain Inventory, as described below:

a. *Psychosocial variables: West Haven-Yale Multidimensional Pain Inventory (MPI;*

Kerns, Turk, & Rudy, 1985; Appendix F). The MPI is a 60-item inventory of

patients' psychosocial and behavioral responses to chronic pain. The three parts

of the MPI have high internal consistency ($\alpha = 0.70$ to 0.90) and stability ($\alpha =$

0.62 to 0.91). Most important to the present study, the MPI assesses social

influences on chronic pain and was used in this study to indicate operant

contributors to chronic pain. Part II on the MPI assesses the response of the

respondent's significant other to the patient's pain. As described in the literature

review above, three response styles were identified: punishing, solicitous, and

distracting. The factor analysis employed in the development of the measure

revealed the three distinct response styles, but further analysis of the measure did

indicate significant correlations between the three response types ($r = 0.24$ to

0.49, all $p < .05$). As described earlier in this paper, some researchers have

questioned the independence of the three response styles (e.g., McCracken, 2005;

Bernstein et al., 1995).

4. Pain

    a. *Pain sensitivity: Pressure pain threshold (scores were indicated on the Low Back*

       Pain Testing Data Sheet, Appendix G). Experimental pain was induced using a

       pressure algometer with a 1 cm square circular tip (Somedic Production AB,

       Sollentuna, Sweden), applied to the deltoid muscle on the dominant arm.

       Pressure is applied at a rate of approximately 1 kg/cm^2/second. The maximum

       force that could be applied was 10 kg/cm^2. Participants were asked to indicate to

       the examiner when the sensation they experienced first started to become painful.

       Pain pressure thresholds from three trials were taken from the deltoid muscle on

       the dominant arm. This method of experimental pain stimulation has been

       effectively utilized in studies of chronic pain patients, most recently in identifying

       the relationship of experimental and clinical pain measures in chronic pain

       patients (Geisser et al., 2007a).

b. *Current pain levels.* See section below on ongoing assessments over a 5-day

period.

c. *Anticipated pain levels.* See section below on ongoing assessments over a 5-day

period.

5. Perceived disability

a. *Self-report measure of disability: Roland-Morris Disability Questionnaire*

(RMDQ; Roland & Morris, 1983; Appendix H). The RMDQ is a 24-item self-

report disability instrument that assesses disability in low back pain patients,

conceptualized as inability to complete daily activities. The questions for the

RMDQ were initially selected from the Sickness Impact Profile. The

questionnaire has high internal consistency ($\alpha = 0.93$) and test-retest reliability (α

$= 0.91$).

6. Actual physical ability

a. *Objective measure of functioning: 6-minute walk (scores were indicated on the*

Low Back Pain Testing Data Sheet, Appendix G). Participants were asked to walk

as quickly as possible for 6 minutes to assess their physical ability. The walk was

conducted in a seldom-used corridor, with markings on the floor every 10 feet

from 0 to 50 feet. The participants walked back and forth on this 50-foot stretch

for the 6 minutes of the test. Physical ability was measured as the total number of

feet walked during the 6-minute test. In addition to total feet walked: (1) heart

rate was monitored for safety reasons, with a threshold of 80% of maximum heart

rate; and (2) participants were asked to rate their level of pain before and after the

walking test and Rating of Perceived Exertion after the test. Previous studies

have validated brief walking tests as a valid and reliable measure of physical

ability in chronic pain patients (Harding et al., 1994; Lee, Simmonds, Novy, &

Jones, 2001; Simmonds et al., 1998)

Ongoing assessments over a 5-day period. Over the course of five days,

participants were repeatedly evaluated for (a) ambulation and (b) pain intensity, variables

that are not stable over time. Experts suggest a minimum of three days and prefer five days

to ensure an accurate assessment of typical physical functioning (Verbunt, Huijnen, & Koke,

2009).

a. *Ambulatory monitoring*. Each participant was fitted with an Actiwatch (Mini Mitter

Co, Bend, OR) ambulatory monitoring device that monitored real-time levels of

activity in 15 second intervals. The Actiwatch is a wrist-worn device but is highly

associated with whole-body movement (Patterson et al., 1994). Activity levels were

analyzed based on the available data, including discrete data points, used in time-

series analysis and aggregate summaries (daily summaries and averaging values over

the 5-day period) for comparison against the global measures assessed during

evaluation (Kop et al., 2005; Murphy et al., submitted). Because participants wore

the watch continuously for 5 days, it was necessary to establish participants' wake-up

and bed times to more accurately document their activity levels over the course of

each day. A previously-established algorithm was used for this purpose (Kop et al.,

2005; Murphy et al., submitted for publication). Additionally, a paper log was

maintained by participants as a back-up and for cross-comparison, including logs of

activity in two-hour blocks and periods when Actiwatch was removed, such as while

showering (log for one day is included in Appendix I; participants received five sets

of the log to account for the 5 days of data collection). Finally, the model of
Actiwatch used in the present study was a single unit that contained all measurement
and storage components in one durable, sealed case. The use of such a device
prevented the data loss that has affected other studies that used multi-component
devices with sensors connected by wire to a main storage device (van Weering et a.,
2009).

b. *Pain levels*. For each waking four-hour interval, participants were asked to record
both (i) their current pain level and (ii) the amount of pain expected over the
following four-hour period. Patients were prompted with an alarm programmed into
their actigraph watch to record their current and anticipated pain intensities on a 0-10
Numerical Rating Scale (NRS; Jensen & Karoly, 2001), with the scale from 0 = no
pain to 10 = extremely severe pain. Recording pain levels with this frequency has
been successfully completed in previous studies (e.g., Geisser, Robinson, &
Richardson, 1995) and has been suggested to be significantly more accurate and less
biased than using delayed recall methods (Broderick, Schwartz, Vikingstad,
Pribbernow, Grossman, & Stone, 2008; Morren, van Dulmen, Ouwerkerk, &
Bensing, 2009). The Actiwatch included a function that allowed patients to directly
input their pain intensity into the watch. Additionally, a paper log was maintained by
participants as a back-up and for cross-comparison (log for one day is included in
Appendix K; participants received five sets of the log to account for the 5 days of data
collection).

Design

This study was a descriptive, single group design with both cross-sectional and repeated measures data, utilizing correlational and time-series analyses. With the exception of a brief assessment of experimental pain, the variables in the study were not manipulated. The study was conducted prior to treatment for a chronic low back pain problem to supplement the knowledge base about the factors that contribute to disability in untreated chronic back pain patients.

Procedures

Recruitment. Recruitment occurred during initial psychology evaluations. In the case of patients referred to the Multidisciplinary Spine Treatment (MST) program, the visit was an evaluation for enrollment in an 8-week program including psychology, physical therapy, and occupational therapy. Patients who were not referred to the MST program were likely to have been referred for only psychology treatment and were recruited during their initial visit for psychological care.

For this study, the evaluating psychologist recruited the participant using the Psychologist Screening Form (Appendix A). Individuals who indicated an interest in participating, and passed initial screening, submitted their name and phone number to their clinician, who passed the information on to the primary investigator. The primary investigator called the participant to screen the participant for eligibility and scheduled a visit to the research laboratory. Participants were scheduled to participate in the study as soon as they were able, with the goal of participation being complete before the patient began treatment for their pain problem.

Baseline assessment. The initial assessment typically occurred on a Thursday or Friday. When participants visited the research laboratory, the procedure was as follows:

1. The participant completed the informed consent for the study.

2. The participant received the battery of questionnaires listed in the Measures section.

3. The pain sensitivity test was conducted using the pressure algometer.

4. The 6-minute walk was conducted in a hallway adjacent to the research laboratory.

5. The participant was trained to use the actiwatch for the ongoing assessment of physical activity, pain levels, and anticipated pain levels.

Ongoing assessments over a five-day period. The five-day period of ongoing assessment typically began on the Monday following the initial visit. The Primary Investigator called the participant to remind him or her that the ongoing assessment period had begun. During this ongoing assessment, the participant had two tasks.

The first task was to wear the actiwatch at all times (other than bathing). The watch was preprogrammed to activate itself on the first day of the study, so the participant simply needed to wear the watch.

The second task was to enter ratings into the actiwatch every four hours during waking hours. The watch was also programmed to sound an alarm at each of these four hours during waking hours. (As part of the initial assessment, participants indicated their normal sleep hours, so that an alarm on the watch could be preprogrammed to only sound in the four-hour intervals during waking hours). Each time the alarm sounded, the participant entered his or her current pain level and anticipated pain level directly into the watch. Additionally, he or she recorded the same values in a written log book. The procedure outlined above parallels recently published recommendations for ensuring high compliance

in data collection, including entering pain ratings into an electronic device, requiring fewer than 20 items to be entered at a time, reminding participants with an alarm, accompanying matierals with a user's manual, and paying participants for their efforts (Morren, van Dulmen, Ouwerkerk, & Bensing, 2009).

Post-assessment. During the week following the five-day assessment period, the participant returned the actiwatch and log book to the researcher.

Compensation. During the post-assessment visit, participants were compensated for their participation. The patient earned a maximum of $60 for participation, with the following schedule of compensation: $10 for the initial laboratory visit and $10 for each of the five days of ongoing research participation. All necessary funding for participant compensation was attained through a Student Award Program grant (# 1265.SAP) from the Blue Cross and Blue Shield of Michigan Foundation and through an internal grant provided by the University of Michigan's physical therapy department.

Preliminary and Exploratory Analyses

Preliminary analyses included the calculation of basic descriptive statistics regarding the sample, including demographic information and mean scores on the measures employed in the study. These descriptive statistics describe the participant population, as well as participants' responses, and include frequencies, means, standard deviations, and ranges as appropriate.

Bivariate zero-order correlation coefficients were used in exploratory analyses to identify relationships between disability and predictors of disability, as well as within the predictor

group and within the disability measures. These analyses provided information regarding the following questions:

1. What is the magnitude of the relationships between the measures of disability: actual activity, physical ability, and perceived disability?

2. What is the magnitude of the relationships between the predictors of disability that were assessed in the baseline assessments: pain sensitivity, depression, pain catastrophizing, pain anxiety, negative spousal responses, solicitous spousal responses, and distracting spousal responses?

3. What is the magnitude of the relationships between the measures of disability and their predictors?

The results of these analyses allow for the following:

1. Comparison of the relationships in the present study to relationships identified previously in the literature.

2.   Identification of relationships that warrant specific attention in more complex analyses.

Analysis of Research Question 1

Research question 1: Which contributes to more of the variance in chronic back pain

disability: pain or the anticipation of pain?

Hypothesis 1:   It was hypothesized that the anticipation of pain would contribute to

more of the variance in chronic back pain disability than current pain.

Analysis: Time series analysis

The time-series analysis assesses the relationship between data points that are repeatedly measured, allowing for the identification of meaningful relationships among variables as they change over time. In the present study, physical activity, current pain level, and anticipated level were assessed at multiple time points per day, and the resulting 20 assessments per person were compared in the analysis.

The three variables utilized in the time-series analysis were defined as follows: Physical activity was utilized as a representative of disability and served as the dependent variable for this and other analyses in the present study. The time series was conducted to assess for similarities or differences in the relationships of current pain and anticipated pain to physical activity. The reasons for including and assessing for these two pain variables is rooted in the literature: Current pain levels represent the traditional measure of pain that was dominant in the mind-body dualism approach to chronic pain.   The anticipation of pain is a proxy for the important psychosocial factors that may contribute to disability, such as those commonly considered within fear-avoidance, catastrophizing, and depression. Current pain and anticipated pain ratings were collected every 4 hours and were compared with average activity levels (monitored by the Actiwatch) over the subsequent 4 hours.

The time series analysis utilized in this study had two components. First, it was important to determine the presence or absence of autocorrelation in the data, which is the degree of serial dependence of the data in a time series. To properly assess time-series data, it is important to insure that the observations from one time point to the next are random occurrences and are not an expected relationship based on another influence. Second, cross-correlations were calculated to determine the relationships present in the data while

controlling for the presence or absence of autocorrelation. The cross-correlations were calculated separately for each individual, allowing for the identification of individual participants who demonstrated significant relationships in pain and/or anticipated pain with physical activity. The individual cross-correlations were then analyzed in a single sample t-test to determine if the mean of the cross-correlations was significantly different from zero.

The analyses used to test the current hypothesis were previously used by Geisser et al. (1995) to assess the relationship of numerous variables with surface electromyography monitoring, as well as by Liszka-Hackzell and Martin (2004) to assess the relationship of pain and physical activity. To test the hypothesis, the time-series was calculated to assess the relationship of current and anticipated pain with the physical activity that followed over the next four hours. However, an additional benefit of using the time-series analysis is to use lag analyses. Lag analyses assess for the relationship of offset relationships. For example, it might be important to understand not just how pain is related to the activity that follows over the next four hours, but also to understand how pain is related to activity that follows one interval later (four to eight hours after the reporting of the pain). A lag analysis can be conducted to make this assessment. In the present analysis, lags were calculated as exploratory analyses to elucidate the relationships.

Analysis of Research Question 2

Research question 2: Which of the three primary models of chronic back pain disability – pain, cognitive-behavioral, and social/operant – accounts for the most variance in chronic back pain disability?

Hypothesis 2:   It was hypothesized that social factors would account for more of the

variance in chronic back pain disability than the cognitive-behavioral

or pain factors.

Primary analysis: Ordinary Least Squares Regression

Secondary analysis: Multiple Regression

Primary analysis. The purpose of the present analysis was to determine the variance

in physical activity (measured through actigraphy) accounted for by each of the three primary

potential contributors to chronic back pain disability, as assessed simultaneously through an

Ordinary Least Squares regression (OLS). Whereas the analysis for hypothesis 1 is based

entirely on repeated measures data, OLS is used for panel data, which is a data set that

includes both cross-sectional and repeated measures data. Thus, the OLS analysis includes

the stable constructs that were each measured only one time (i.e., the baseline assessments

including questionnaires and clinical tests). The OLS analysis also includes the highly

variable, repeated measures data collected during the ongoing assessments over a five day

period (i.e., pain and expected pain).

In many ways, OLS is similar to multiple regression. However, multiple regression

requires all data to be in cross-sectional form and, thus, would require collapsing the repeated

measures variables into single measures, thus yielding one value for each variable per

participant. Instead, in OLS, the data are analyzed by assessment point instead of by

participant. Therefore, in a sample of 20 participants with 20 measures per participant, the

analysis is conducted on 400 data points, whereas a multiple regression would be calculated

on only 20 data points. The analysis then assesses the value of each variable when all other

variables are held constant, and can be further clustered to control for the effect of individual participants.

The mechanics of the OLS were as follows: The dependent variable in the model was average activity. Predictors included all demographic variables, as well as the three variables representative of the pain model (current pain, anticipated pain, pain sensitivity), the three variables representative of the cognitive-behavioral model (depression, catastrophizing, pain anxiety), and the three variables representative of the social model (negative responses, solicitous responses, distracting responses). Current and anticipated pain were repeated measures variables, whereas the other seven variables were cross-sectional data. Additionally, a variable was entered into the model to control for individual participants and, specifically, to cluster the individual's data together for comparison against each other participant's cluster of data.

The analysis yields information about each individual predictor, including a regression coefficient, t-value, and significance. The regression coefficient denotes the amount the dependent variable changes with a single unit of change in the predictor, holding all other predictors constant. The t-value and related significance level help in the identification of significant predictors. From this step, significant predictors of physical activity can be identified.

The data were then further tested through a second OLS regression to directly compare the pain model, cognitive behavioral model, and social model. The dependent variable was again physical activity. In order to evaluate relative contribution of the models, (as opposed to evaluating the relative contribution of each of the nine predictors), three new composite variables representing the three models were created. This was done by collapsing

the three representative predictors from each model into a single variable to represent the model. More specifically, the procedure for doing so was as follows: First, the original predictors were converted to z-scores to standardize their units. Second, the individual predictors were evaluated for their theoretical positive or negative effect on physical activity (e.g., higher pain is assumed to have a negative effect, but higher pain tolerance is assumed to have a positive effect). Third, the scores were combined to form the variable representative of the theoretical model. Creation of such composite variables has precedence in the literature, most notably in a chronic pain study using similar variables (Kerns, Rosenberg, & Otis, 2002).

Last, the data were assessed through a series of three regressions to identify the variance in physical activity accounted for by the nine predictors (representatives of the explanatory models) utilized in this study, as opposed to variables that could be attributed to all other individual characteristics of each participant in the study. The first regression included the nine predictors (representatives of the explanatory models) and dummy-coded variables for the participants, to yield the total amount of variance accounted for by the observed variables and participant characteristics. The second regression included only the nine predictors (representatives of the explanatory models), to identify the amount of variance in physical activity accounted for by the predictors alone, without participant characteristics. The third regression included only the dummy-coded variables for the participants, to identify the amount of variance in physical activity accounted for only by characteristics attributable to the individual participants. It is notable that regression does not control for repeated measures and, thus, the data can only be assessed at the level of the entire regression model. Although the statistical analysis produces coefficients for the

individual variables, the lack of control for repeated measurement would disallow interpretation of the values of the individual coefficients.

Secondary analysis. In addition to testing the three theoretical models against physical activity, it was also of interest to test the three theoretical models against two other measures of disability: perceived disability and physical ability. Because these two predictors were each evaluated as cross-sectional data, multiple regressions were performed. Unfortunately, a larger sample size is needed to have sufficient power to run this analysis. Despite this, the following analyses are reported in this study under the qualification that they were significantly underpowered. To determine which model accounts for the most variance in disability, three regressions were conducted. These three multiple regressions included the following variables:

Pain:

| Average pain over 5 day actigraphy
Average anticipated pain over 5 day actigraphy
Experimentally induced pain | → | Disability |

Cognitive-behavioral factors:

| Pain anxiety (TSK)
Depression (CES-D)
Pain catastrophizing (PCS) | → | Disability |
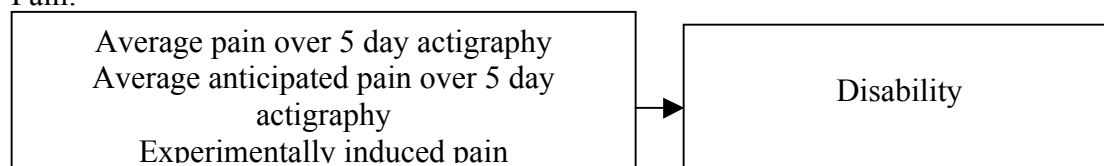
Social factors (all are scales from Part II on the MPI):

| Solicitous responses
Distracting responses
Punishing responses | → | Disability |

The above set of three multiple regressions were completed three times. In each set a different disability variable was regressed onto the predictors as indicated above. In the first set, disability was operationalized as the average level of activity over the course of the

study, as measured by actigraphy. In the second set, disability was operationalized as perceived disability, as measured by the Roland-Morris Disability Questionnaire. In the third set, disability was operationalized as functional ability, as measured by the 6-minute walk. The purpose of using the three different disability measures was to determine if the strength of the various models was related to the type of disability assessment.

RESULTS

The present study assessed for the relationship of three categories of predictors –

pain, cognitive-behavioral factors, and social factors – to quantity of physical activity. The

following analyses explore these relationships. Exploratory analyses were conducted to

elucidate participants' scores on the predictors, as well as the relationship between the

predictors. Two analyses were conducted to assess predictors of physical activity: the first

utilized a time-series analysis to explore the real-time relationship of pain and physical

activity, as well as anticipated pain and physical activity; the second utilized random-effects

regression analyses to identify the relative variance in physical activity accounted for by each

of nine predictors and each of three theoretical models.

Exploratory Analyses

The following describes participants' scores on the primary questionnaires and

clinical tests utilized for this study (see Table 1). Participants' mean scores on the CES-D,

PCS, and TSK, were all high, indicating significant levels of psychological distress.

Specifically, a majority of participants scored above the clinical cutoff on the CES-D (n = 16,

80%) and above the mean possible score on the PCS (n = 10, 50%) and the TSK (n = 17,

85%). The rate of depression is higher than the rates commonly cited in the literature on

chronic back pain (30%-54%; Banks & Kerns, 1996), but is consistent with the estimate that

50-80% of medical patients experience the somatic-vegetative symptoms of depression

(Doan & Wadden, 1989; Wesley, Gatchel, Polatin, Kinney, & Mayer, 1991). However, the

scores on all of the assessments reflected significant heterogeneity among the participants, as

evidenced by large standard deviations and score ranges. Thus, while the CES-D, PCS, and

TSK all evidenced high levels of distress, and the scale scores on the MPI reflected average

responses by significant others, individual participants indicated scores that reflect the entire

spectrum of score possibilities. Thus these scores reveal the heterogeneity of the population

that was studied.

Table 1

Mean, standard deviation, and range for participant scores on assessments of pain

sensitivity, cognitive-behavioral variables, significant others' responses to pain, and

disability.

Predictor	Mean	SD	Range
Pain variable			
Pain sensitivity	3.78	1.53	1.50 – 7.47
Cognitive behavioral variables			
CES-D	24.20	13.25	3 – 50
PCS	26.40	12.24	4 – 44
TSK	30.55	7.14	18 – 46
Significant others' responses			
MPI negative	2.66	1.61	0.25 – 5.50
MPI solicitous	2.95	1.38	0.00 – 5.50
MPI distracting	2.13	1.52	0.00 – 6.00
Disability measures			
RMDQ	13.95	3.05	8 – 20
6-minute walk	1087.75	263.33	630 - 1715

The following describes the relationship between the primary questionnaires and clinical tests utilized for this study (see Table 2). Pearson correlation coefficients were calculated to determine the strength of each relationship. Statistically significant relationships were noted among the three variables representing the cognitive-behavioral predictors, depressive symptoms, pain anxiety, and pain catastrophizing (CES-D, TSK, PCS; r's = 0.48 to 0.79, all $p < .05$). Additionally, perceived disability was correlated at a statistically significant level with all three of the aforementioned variables (r's = 0.45 to 0.76, $p < .05$). Finally, the negative spousal response (MPI negative) was significantly correlated with pain anxiety and perceived disability (r's = 0.45 to 0.50, $p < .05$), while the distracting and solicitous spousal responses (MPI distracting and MPI solicitous) were significantly correlated with each other ($r = 0.63$, $p < .01$).

Table 2

Correlations between the baseline measures utilized in this study

	1.	2.	3.	4.	5.	6.	7.	8.
Pain variable								
1. Pain sensitivity	--							
Cognitive behavioral variables								
2. CES-D	-0.28	--						
3. PCS	-0.26	0.79***	--					
4. TSK	-0.28	0.55*	0.48*	--				
Significant others' responses								
5. MPI negative	-0.31	0.70**	0.40	0.50*	--			
6. MPI solicitous	-0.16	-0.13	-0.10	-0.12	-0.05	--		
7. MPI distracting	-0.19	-0.10	0.05	0.16	0.08	0.63**	--	
Disability measures								
8. RMDQ	-0.01	0.72***	0.76***	0.45*	0.58**	0.10	0.13	--
9. 6-minute walk	-0.01	-0.13	-0.20	0.22	-0.31	-0.05	0.21	0.43

* $p < .05$, ** $p < .01$, *** $p < .001$

Relationship of Pain and Expectation of Pain to Physical Activity

Research question 1: Which contributes to more of the variance in chronic back pain

disability: pain or the anticipation of pain?

Hypothesis 1: It was hypothesized that the anticipation of pain would contribute to

more of the variance in chronic back pain disability than current pain.

A time series analysis was utilized to determine the relationship between physical

activity and the predictor variables, current pain and anticipated pain. First, the data were

inspected for autocorrelation. For each participant, autocorrelation analyses were conducted

for their pain, anticipated pain, and average physical activity data. No instances of

autocorrelation were observed for any of the variables in any of the participants.

Next, the data were analyzed for cross-correlations between pain and average

physical activity, as well as anticipated pain and average physical activity for each

participant. To test the data as a group, the mean cross-correlations were calculated and a

one-sample t-test was conducted to assess whether the cross-correlations were significantly

different from zero (see Table 3). The results suggest that neither pain nor anticipated pain

was significantly related to physical activity. The results were also inspected for the

possibility of using a lag analysis to identify meaningful relationships between pain or

anticipated pain and physical activity (e.g., pain at the first interval predicts activity two

intervals later). However, the relationships did not differ when lags were employed. On the

basis of the above analysis, therefore, the first hypothesis was not supported.

Table 3

T-test to assess for a significant difference from zero for the pain-physical activity cross-correlation and anticipated pain-physical activity cross-correlation

Relationship	Mean	SD	t-score
Pain-physical activity	-0.03	0.28	-0.41
Anticipated pain-physical activity	-0.05	0.28	-0.82

However, further inspection of the data revealed that two groups of participants were present, some with positive cross-correlations and some with negative cross-correlations. As a result, when collapsing their cross-correlations, the scores canceled each other out. For example, for anticipated pain, participant 005 had a significant cross-correlation of -0.58, while 014 had a significant cross-correlation of 0.54. Their mean cross-correlation, however, was a mere -0.02. Therefore, for exploratory purposes, the t-test was repeated, but this time was calculated twice for the pain-physical activity and twice for the anticipated pain-physical activity relationship, with one calculation for the participants with positive correlations (noted as "positive") and one for participants with negative correlations (noted as "negative"). It is notable that there were two patients in the study who switched groups. One patient has a positive pain relationship and a negative anticipated pain relationship, while the other had a negative pain relationship and a positive anticipated pain relationship. This dichotomization of the data has relevance for the clinical literature (e.g., Otis, 2007; Thorn, 2004), where positive and negative relationships represent commonly observed behavior patterns in the chronic low back pain population. Thus, it would not be unexpected to have distinct groups within the participants of this study, representing the positive and negative

relationships between pain, anticipated pain, and physical activity. When analyzed in this manner, the t-test revealed that all four groups had mean cross-correlations that were significantly different from zero (all $p < .01$; see Table 4), thus suggesting that the relationship of both pain and anticipated pain with disability is significant after correcting for the direction of the relationship has been taken into consideration.

Table 4

T-test to assess for a significant difference from zero for the pain-physical activity cross-correlation and anticipated pain-physical activity cross-correlation, grouped by positive and negative relationships

Relationship	N	Mean	SD	t-score
Pain-physical activity (positive)	7	0.26	0.15	4.51 **
Pain-physical activity (negative)	12	-0.21	0.15	-4.54 **
Anticipated pain-physical activity (positive)	7	0.23	0.16	3.89 **
Anticipated pain-physical activity (negative)	12	-0.23	0.17	-4.58 **

$* p < .05, ** p < .01, *** p < .001$

To assess whether the two groups differed significantly from one another in terms of their mean scores on the TSK, a t-test was run. The t-test assessed whether the mean score on the TSK differed for those who had positive cross-correlations from those who had negative cross-correlations. The results suggest that there was no significant difference between groups ($t = -.93$ for both pain and anticipated pain; see Table 5). However, Cohen suggests that in addition to testing for significance, one may also test for the effect size to

estimate the strength of a finding. For t-test, Cohen's (1988) d is calculated by dividing the mean difference by the pooled standard deviation. The results suggest that the effect sizes observed for the mean difference in TSK (d = 0.47 for both pain – physical activity cross-correlation and anticipated pain – physical activity cross-correlation; see Table 5) were in the medium range, as Cohen specifies medium d = 0.50. This provides some evidence for fear-avoidance as a means of grouping participants within the pain – physical activity and anticipated pain – physical activity relationships.

Table 5

T-test and effect size of mean differences in fear-avoidance scores between participants with positive or negative relationships between pain and physical activity and expected pain and physical activity

Relationship	t	p	Effect size (d)
Fear-avoidance for pain – physical activity	-.93	0.37	0.47
Fear-avoidance for anticipated pain – physical activity	-.93	0.37	0.47

Similarly, to assess whether the two groups differed significantly from one another in terms of their mean algometer scores, a t-test was run. The t-test assessed whether the mean algometer score differed for those who had positive cross-correlations from those who had negative cross-correlations. The results suggest that there was no significant difference between groups (t = -1.06 for pain and t = -0.81 for anticipated pain; see Table 6). Again using Cohen's d for effect size, the results suggest that the effect sizes observed for the mean difference in algometer scores (d = 0.51 for the pain – physical activity cross-correlation and

d = 0.38 for the anticipated pain – physical activity cross-correlation, see Table 6) were in the medium range. This provides some weak evidence for pain sensitivity as a means of grouping participants within the pain – physical activity and anticipated pain – physical activity relationships.

Table 6

T-test and effect size of mean differences in algometer scores between participants with positive or negative relationships between pain and physical activity and expected pain and physical activity

Relationship	t	p	Effect size (d)
Pain sensitivity for pain – physical activity	-1.06	0.31	0.51
Pain sensitivity for anticipated pain – physical activity	-.81	0.43	0.38

Last, and similar to the two previous analyses, to assess whether the two groups differed significantly from one another in terms of their work status, a t-test was run. The t-test assessed whether the patient's work status differed for those who had positive cross-correlations from those who had negative cross-correlations. The results suggest that there was no significant difference between groups ($t = 2.87$ for pain and $t = -0.42$ for anticipated pain; see Table 7). Again using Cohen's d for effect size, the results suggest that the effect sizes observed for the mean difference in algometer scores (d = 0.77 for the pain – physical activity cross-correlation and d = 0.18 for the anticipated pain – physical activity cross-correlation, see Table 7) were in the large range for pain and the small range for anticipated pain. This provides evidence for work status as a means of grouping participants within the

pain – physical activity relationship and weak evidence for work status as a means of grouping participants in the anticipated pain – physical activity relationship.

Table 7

T-test and effect size of mean differences in work status between participants with positive or negative relationships between pain and physical activity and expected pain and physical activity

Relationship	t	p	Effect size (d)
Work status for pain - physical activity	2.87	0.10	0.77
Work status for anticipated pain - physical activity	-0.42	0.67	0.18

Contribution of Pain, Cognitive-behavioral Factors, and Social Factors to Disability

Research question 2: Which of the three primary models of chronic back pain disability – pain, cognitive-behavioral, and social/operant – accounts for the most variance in chronic back pain disability?

Hypothesis 2: It was hypothesized that social factors would account for more of the variance in chronic back pain disability than the cognitive-behavioral or pain factors.

Hypothesis 2 was tested through primary and secondary analyses. The primary analysis employed OLS regression to evaluate the relative variance in physical activity (as measured by actigraphy) accounted for by variables representative of the three primary models (pain, cognitive-behavioral, social). The secondary analysis employed multiple

regression to compare the amount of variance accounted for by each of the three primary

models in each of three measures of disability – physical activity, perceived disability, and

physical ability.

  Primary analyses. The nine predictors (representatives of the three models) and

demographics variables were simultaneously tested through OLS regression, with a cluster

analysis to control for the repeated measures within each participant. The overall model

accounted for 28% of the variance ($R^2 = 0.28$, $F = 131.96$, p < .001; see Table 8). More

specifically, three predictors accounted for a statistically significant amount of the variance

in physical activity, suggesting that patients who were more sensitive to pain (Estimate =

38.57, p < .001), had higher levels of fear of movement/(re)injury (Estimate = -11.27, p <

.01), and received more solicitous spousal responses (beta = -64.68, p < .01) engaged in less

activity. Additionally, patients who were unemployed due to their pain problem (beta = -

258.93, p < .001) and had a longer duration of their pain problem (Estimate = -1.73, p < .001)

engaged in less activity. Further, the output of OLS regression can be interpreted even more

informatively, by virtue of the fact that the estimate values represent the change in the

outcome variable relative to one unit change in the predictor while holding all other

predictors constant. The outcome variable in the present analysis was physical activity,

measured in activity counts by the actiwatch. For the predictors, the units were as follows:

pain sensitivity = kilograms of pressure, fear of movement/(re)injury = score on TSK, and

solicitous responses = subscale score on the MPI. For the demographics variables, the

unemployment variable was tested as a dichotomous variable relative to all other categories

of workers and the duration of the pain problem was calculated in months of pain.

Therefore, the OLS regression model suggested that patients had 38.57 more actiwatch activity counts per four hours for every additional unit increase in their pain pressure threshold (kg/cm^2) they tolerated on the algometer when all other variables were held constant. In contrast, patients had 11.27 fewer actiwatch activity counts per four hours for every additional point they scored on the TSK when all other variables were held constant. Similarly, patients had 64.68 fewer actiwatch activity counts per four hours for every additional point they scored on the Solicitous MPI scale when all other variables were held constant. With respect to the demographic variables, patients who were unemployed had 258.83 fewer actiwatch activity counts per four hours than all patients in all other categories of employment, when all other variables were held constant. In addition, patients had 1.73 fewer actiwatch activity counts per four hours for every additional month they were unemployed, when all other variables were held constant.

To control for the potential biasing effects of time of day or day of the week, the same analyses were repeated including time and day variables. Results did not change significantly. The model continued to predict 28% of the variance in physical activity, neither time of day nor day of the week emerged as significant predictors, and the same demographics variables and predictors remained significant as in the original analysis.

Table 8

Ordinary Least Squares Estimation of the determinants of physical activity measured by actigraphy

	Estimate	Standard Error	*t*	*p*
Intercept	734.86	149.77	4.91	0.00
Demographics variables				
Age	2.60	2.90	0.90	0.38
Sex	-139.49	77.91	-1.79	0.09
Marital status (married vs. not)	52.28	33.07	1.58	0.13
Education (years)	20.35	12.12	1.68	0.11
Employment status (unemployed due to pain problem vs. all others)	-258.83	72.57	-3.57	0.00
Litigation for pain problem	13.40	53.22	0.25	0.80
Duration of pain (months)	-1.73	0.59	-2.93	0.01
Pain model variables				
Pain	5.37	9.65	0.56	0.58
Anticipated pain	-5.93	10.81	-0.55	0.59
Pain sensitivity	38.57	9.08	4.25	0.00
Cognitive-behavioral model variables				
Depression	4.87	2.45	1.99	0.06
Pain catastrophizing	-0.23	1.36	-0.17	0.87
Fear of movement/(re)injury	-11.27	4.78	-2.36	0.03
Social model variables				

Negative responses	1.11	15.60	0.07	0.94
Solicitous responses	-64.68	19.76	-3.27	0.00
Distracting responses	8.78	18.09	0.49	0.63

The nine predictors inserted in the model above were representatives of the three theoretical models of disability predictors. To further evaluate the models, the three predictors representative of each model were collapsed into a single variable to represent the model. These three composite variables were then analyzed through the same OLS regression as above, this time to determine the theoretical model's contribution to the variance in physical activity. The overall regression model accounted for 20% of the variance ($R^2 = 0.20$, $F = 7.49$, p < .01; see Table 9). The composite variable representing the Social Composite Model emerged as the only model accounting for a statistically significant amount of the variance in physical activity (beta = -61.64, p < .05). No other predictors or demographics variables accounted for a statistically significant amount of the variance in physical activity.

Table 9

Ordinary Least Squares Estimation of the Effect of each theoretical model on physical

activity measured by actigraphy

	Estimate	Standard Error	*t*	*p*
Intercept	320.39	152.06	2.11	0.05
Demographics variables				
Age	3.28	3.57	0.92	0.37
Sex	-28.97	97.01	-0.30	0.77
Marital status (married vs. not)	45.11	51.99	0.87	0.40
Education (years)	-3.33	8.76	-0.38	0.71
Employment status (unemployed due to pain	-146.95	84.21	-1.74	0.10
problem vs. all others)				
Litigation for pain problem	93.50	96.33	0.97	0.34
Duration of pain (months)	-0.46	0.51	-0.90	0.38
Theoretical models				
Pain composite model	-51.85	44.17	-1.17	0.25
Cognitive-behavioral composite model	-20.82	24.99	-0.83	0.42
Social composite model	-61.64	26.36	-2.34	0.03

To gain additional information about the predictors analyzed above, a series of

regressions were run to further describe the variance in physical activity (see Table 10 for

results). The first regression included the nine theoretically-based predictors and the

participants, to describe the amount of variance accounted for by the measured predictors and

the participants. This model was statistically significant ($F = 7.99$, $p < .001$) and accounted

for 29% of the variance in physical activity. A second regression was run including only the

theoretically-based predictors, to identify the amount of variance in physical activity

accounted for by the theoretically-based predictors alone, without considering participant-

specific reasons. This model was also statistically significant ($F = 8.93$, $p < .001$) and

accounted for 17% of the variance. A third regression was run, including only the dummy

codes for the participants, to identify the amount of variance in physical activity accounted

for by any characteristics related to the individual participants. This model was also

statistically significant ($F = 5.88$, $p < .001$) and accounted for 13% of the variance. In sum,

these analyses reveal that the theoretically-based predictors assessed in this study accounted

for 17% of the variance in physical activity, and the remaining amount of variance accounted

for in this study was due to variation unique to the study participants.

Table 10

Regressions to assess for the variance in physical activity accounted for by participants and

theoretically-based predictors together, predictors only, and participants only

Model	F	Adj. R^2
Participants and theoretically-based predictors	7.99***	0.29
Theoretically-based predictors only	8.93***	0.17
Participants only	5.88***	0.13

* $p < .05$, ** $p < .01$, *** $p < .001$

Secondary analyses. In total, nine multiple regressions were run to assess the

contribution of each of the three primary explanatory models (pain, cognitive behavioral, and

social) to each of the three measures of disability (average physical activity, perceived disability, physical ability).

Prior to conducting the analyses, the data were inspected to ensure that they met the assumptions of multiple regression. A high correlation between pain and anticipated pain ($r = 0.95$) suggested multicollinearity between the two variables. As a result, anticipated pain was dropped from the analyses.

The primary disability measure in the present study was physical activity, as assessed through actigraphy. In contrast to the OLS regressions, however, the actigraphy data were collapsed into a single measure for each participant. In the first set of three regression analyses below, physical activity was represented by average activity over the course of the study (see Table 11). The social model accounted for 37% of the variance in physical activity ($F = 3.18$; $p = .05$) and also yielded a substantially higher F and R^2 relative to the other two models.

Table 11

Average physical activity regressed through three multiple regressions onto variables

representative of the Pain, Cognitive-behavioral, and Social models

Model	F	R^2	Dependent variable	Beta	Standardized Beta
Pain	.25	.06			
			Average current pain	-9.58	-0.21
			Pain sensitivity	-3.93	-0.08
Cognitive-behavioral	.52	.09			
			Depression	-1.30	-0.22
			Catastrophizing	1.79	0.27
			Fear of movement/(re)injury	-2.88	-0.26
Social	3.18*	.37			
			Negative	-16.74	-0.34
			Solicitous	1.71	0.03
			Distracting	-26.25	-0.50

* $p < .05$, ** $p < .01$, *** $p < .001$

A second set of three regression analyses was run, using perceived disability, as

assessed through the Roland-Morris Disability Questionnaire (see Table 12) as the dependent

variable. Multiple regression analyses revealed the cognitive-behavioral model accounted

for 62% of the variance in perceived disability (F = 8.82; $p < .01$)

Table 12

Perceived disability as assessed by the Roland Morris regressed through three multiple

regressions onto variables representative of the Pain, Cognitive-behavioral, and Social

models

Model	F	R^2	Dependent variable	Beta	Standardized Beta
Pain	3.23	.29			
			Average current pain	1.06	-0.56
			Pain sensitivity	-.32	-0.16
Cognitive-behavioral	8.82**	.62			
			Depression	.07	0.31
			Catastrophizing	.13	0.50
			Fear of movement/(re)injury	.02	0.04
Social	2.86	.35			
			Negative	1.10**	0.58
			Solicitous	.29	0.13
			Distracting	.01	0.00

p < .05, ** *p* < .01, *** *p* < .001

      A third set of three regression analyses was run using physical ability, as assessed

through the 6-minute walk test (see Table 13) as the dependent variable, representative of

disability. No variables or models accounted for a statistically significant amount of the

variance in physical ability, though the cognitive-behavioral and social/operant models (17%

and 13% respectively), accounted for substantially more variance than the pain model (4%).

Table 13

Physical ability as assessed by the 6 minute walk regressed through three multiple regressions onto variables representative of the Pain, Cognitive-behavioral, and Social models

Model	F	R^2	Dependent variable	Beta	Standardized Beta
Pain	0.33	0.04			
			Average current pain	-33.69	-.21
			Pain sensitivity	7.32	0.04
Cognitive-behavioral	1.11	0.17			
			Depression	-2.51	-0.13
			Catastrophizing	-6.61	-0.31
			Fear of movement/(re)injury	15.97	0.43
Social	0.81	0.13			
			Negative	-46.57	-0.29
			Solicitous	14.96	0.08
			Distracting	-40.20	-0.23

* $p < .05$, ** $p < .01$, *** $p < .001$

The results from these nine regressions suggest that the theoretical models account for substantially different amounts of the variance in disability depending on the disability

measure employed. Thus, the variables that account for a statistically significant amount of the variance in physical activity appear different from those that account for a statistically significant amount of the variance in perceived disability or physical ability.

DISCUSSION

The present study employed questionnaires, clinical tests, and continuous ambulatory monitoring to assess factors that might contribute to differences in physical activity in a chronic low back pain population. Two primary research questions were assessed: The first question was, which contributes to more of the variance in chronic back pain disability: pain or the anticipation of pain? With pain assumed to be a measure of the sensory experience, and anticipated pain assumed to be a measure of cognitive appraisal, this analysis was a broad comparison of biomedical and psychosocial predictors of physical activity. Overall, neither pain nor anticipated pain were significantly related to physical activity, thus lending no support to the hypothesis that anticipated pain would be significantly related to physical activity. However, the analysis yielded interesting results defining four common patterns in the association between physical activity and pain or expected pain (the positive correlation of pain and physical activity, the negative correlation of pain and physical activity, the positive correlation of anticipated pain and physical activity, and the negative correlation of anticipated pain and physical activity).

The second question was, which of the three primary models of chronic back pain disability – pain, cognitive-behavioral, and social/operant – accounts for the most variance in chronic back pain disability? A comprehensive analysis was conducted to simultaneously compare multiple predictors of physical activity that have more commonly been tested separately in studies of chronic pain populations. The results of this analysis revealed that two demographic variables and more importantly, three theoretically-based predictors, accounted for a statistically significant amount of the variance in physical activity. After the theoretically-based predictors were collapsed into groupings based on their theoretical

models, variables comprising a composite variable representing the social model accounted for a statistically significant amount of variance in physical activity, supporting the hypothesis for this research question.

The remainder of this manuscript details how the methods used and analyses conducted in this study were unique in the literature investigating physical activity in chronic low back pain, and how the results of this study serve not only to supplement the existing literature on this population but to contribute to some of the critical theoretical debates at its core.

Pain vs. Anticipated Pain

A primary purpose of the present study was to further evaluate the complex relationship of pain with physical activity, and to compare that relationship to that of anticipated pain and physical activity. Although these relationships have been studied previously with this population, the present study was designed to account for the design limitations of previous studies (e.g., delayed recording of pain symptoms, subjective accounts of physical activity) in an effort to more accurately confirm or dispute the existing body of literature.

Results of analysis of research question 1. The time-series analysis was conducted with the intention of identifying patterns in the relationships of current and anticipated pain with physical activity. The advantages of utilizing time series analyses to assess these relationships were twofold. First, in utilizing repeated-measures data, time series analysis requires a relatively small number of participants. Second, the use of a time-series analysis allowed for a multi-level comparison of results, where outcomes of each participant were

used to identify within-patient patterns, while outcomes for the group of participants as a whole allowed for the identification of common patterns of behavior in this population.

The results of the present study indicated that, taken as a whole, the participants demonstrated no statistically significant relationships between pain or anticipated pain on the one hand, and physical activity on the other. Such a finding is consistent with the current body of literature, which is replete with examples of similarly poor relationships between pain and measures of disability in the chronic low back pain population (e.g., Waddell et al., 2001; Vasudevan, 1992). Of particular relevance to the current study, the other known study that used actigraphy to examine the pain – physical activity relationship also failed to find a relationship of pain and physical activity in chronic low back pain patients (Liszka-Hackzell & Martin, 2004).

However, despite failing to identify meaningful relationships for the participants as a group, and thus failing to support the hypothesis for this research question, visual inspection of the data revealed that for some participants, pain (or anticipated pain) and physical activity were consistently positively related, whereas for other participants, they were consistently negatively related. Exploratory analyses revealed that once patients were grouped based on the *direction* of their pain-activity and anticipated pain-activity relationships, statistically significant relationships indeed became evident. Specifically, the participants demonstrated that when they were confronted with a change in pain level or anticipated a change in pain level, they would invariably make a clear decision to *either* increase *or* decrease activity. The discussion below describes how these patterns of behavior are consistent with common clinical presentations as well as with the existing literature. Additionally, brief explanations are depicted below in Table 14.

Table 14

Matrix describing the positive and negative relationships of pain and anticipated pain with physical activity

| | Relationship with physical activity | |
	Positive	Negative **
Pain	Experiencing pain, but continue with activity and push through the pain (n=7)	Experiencing pain and stop activity to <u>escape from the pain</u> (n=12)
Anticipated pain	Know what is about to happen will be painful, but follow through anyway (n=7)	Know what is about to happen will be painful and <u>avoid activity</u> that could make it worse (n=12)
	** higher on fear of movement/(re)injury, more sensitive to pain	

Interpretation: anticipated pain. The patterns identified for anticipated pain are particularly interesting, as they serve to describe avoidant behavior by pain patients. The following hypothetical situations exemplify these findings: First, consider the individual who believes that physical activity causes his or her pain to increase. This person anticipates an increase in pain whenever he or she has to engage in physical activity. As an example,

this person is about to leave the house for an appointment and, thus, anticipates experiencing an increase in pain. The person reports a higher level of anticipated pain and engages in the increase in physical activity to go to the appointment. This type of situation would be expected to yield a positive correlation between anticipated pain and physical activity.

Not all patients would have attended that appointment. Some patients have a habit of canceling appointments because they "know" that the physical activity required to attend the appointment will cause an increase in pain. Such a person would demonstrate a negative relationship between anticipated pain and physical activity, exemplifying the fear of pain model: when one has a fear of pain and pain is anticipated, he or she will engage in strategies to avoid the anticipated pain (Vlaeyen et al., 1995).

The central feature of the above examples is how a patient manages the threat of an increase in pain. Within this threat management may be an additional important catalyst: how one's opinion of an activity being mandatory or voluntary may contribute to the decisions the participant makes about engaging in physical activity. Patients may engage in activity despite the anticipation of future pain if they feel that the activity is a necessity. Alternatively, patients with a particularly high fear of pain may consider all activities to be optional. However, for many people, going to work, attending appointments, shopping for groceries, and accompanying children to their activities could be examples of mandatory activity. Patients may be more likely to avoid activities that are voluntary or optional, such as window shopping in a mall or meeting a friend for coffee, and may also have more voluntary activities because of the presence of a significant other who can do many of the mandatory activities on the patient's behalf. Although participants were asked to journal their daily activities as part of the current study, they were not asked to comment on the

mandatory versus voluntary nature of their activity. In light of this omission, therefore, although the results of this study appear closely tied to the well-established literature on fear of movement/re-injury, there is no way to determine to what extent the results may be influenced by differences in the quantity of "mandatory" activity in one's life, in addition to or instead of the fear-avoidance response.

Interpretation: current pain. In the case of current pain, participants again provided empirical evidence for two distinct response styles. Patients who demonstrated a positive correlation between their pain and physical activity were likely those patients who were going to "tough it out" despite the pain. However, patients who demonstrated a negative correlation between their pain and physical activity were likely those who were attempting to escape from current pain.

Qualitatively, both of these responses are indicative of the clinical population described in the literature (e.g., Otis, 2007). Specifically, it is most common to observe patients who have greatly decreased their activity due to their pain problem, as is exemplified in the fear-avoidance literature (e.g., Vlaeyen and colleagues, 1995). This, however, does not speak to all of the patients, as a certain (likely smaller) percentage of patients is known to be too active for some or all of the day, thus worsening the pain problem (van Weering et al., 2009). Pain management programs commonly include activity pacing, or the appropriate distribution of activity over time, as a strategy for maximizing activity and minimizing pain (e.g., Otis, 2007).

Clinical implications. The differences in the two basic response styles described above have implications for clinical intervention. Given that the results suggested two distinct behavior patterns each for anticipated pain and current pain, it could be hypothesized

that if clinicians can determine or identify a patient's response style, a lot can be understood about how the patient is likely to behave going forward. Thus, the potential exists that a relatively brief pre-treatment assessment to identify patient response styles could accurately drive treatment decision-making to target likely responses to pain.

This is an important finding, as treatment matching has become a popular topic in the psychology field in general and has been called for in recent studies of chronic pain patients (e.g., Thieme, Turk, & Flor, 2007). For example, in a study of treatments for fibromyalgia patients, a profile of psychological and behavioral response styles to the medical condition was used to accurately inform treatment choice (Thieme et al., 2007). Similarly, the present study suggests that a profile of a patient's behavioral response to current and anticipated pain could be utilized to accurately determine a clinical treatment path for chronic low back pain patients.

Relevance to escape and avoidance behaviors. An interesting note about the behavior patterns identified in the present study is the prevalence of *both* escape and avoidance behaviors in the studied population. Recent studies have expanded the original fear-avoidance model (Vlaeyen & Linton, 2000) to include both the avoidance of pain due to pain anxiety and the escape from pain due to a fear of pain (Asmundson et al., 2004). Within this context, it was defined that individuals avoid something they fear happing in the future (i.e., anticipated pain), whereas they escape from something that is already happening (i.e., current pain). Two of the response styles described above are directly indicative of this model: The negative relationship of current pain and physical activity yields the hypothesis that patients currently in pain limited physical activity in an effort to stop, and thus *escape* from their pain; meanwhile, the negative relationship of anticipated pain and physical activity

yields the hypothesis that patients who anticipate pain limit their physical activity in an effort to minimize, and thus *avoid*, the pain. This study therefore makes a significant contribution to the literature because it is based on monitoring of actual physical behavior, whereas much of the research on the fear-avoidance model is based in cross-sectional questionnaire data. This particular finding was further supported by the supplemental analysis that revealed a moderate effect size for differences in fear-avoidance questionnaire scores between patients who exhibited consistently positive versus consistently negative relationships between physical activity and pain and anticipated pain. Moreover, this finding was supported by the significant difference in work status between participants with positive and negative relationships of pain with activity. Patients with the negative relationship were more likely to be unemployed due to their pain problem. This is particularly indicative of escape behavior and avoidance behavior, where patients may view their work as a cause of increased pain and, therefore, determine that it is advantageous to be off of work to prevent a worsening of pain symptoms.

This additional support further enhances the potential for the patterns identified in this study to drive clinical decision-making. Based on the assessment of a patient, providers could identify whether treatments focusing on fear of pain, such as exposure, would be appropriate for patients. Specifically, treatments focusing on reducing fear-avoidance behavior are predicated on the avoidance of anticipated pain and escape from current pain that were identified for some of the participants in this study. However, such treatments would be inappropriate for those who do not have such tendencies. This is similar to the way treatment-matching was applied in the aforementioned fibromyalgia treatment study, which

utilized a theoretical context to choose between a cognitive-behavioral treatment and an operant treatment (Thieme et al., 2007).

Relationship of pain sensitivity to the relationship of pain and anticipated pain with physical activity. In addition to the observed group differences in fear-avoidance, supplemental analyses revealed moderate effect sizes for differences in pain sensitivity between patients who exhibited consistently positive versus consistently negative relationships between physical activity and pain and anticipated pain. Specifically, patients with negative relationships between their physical activity and pain and anticipated pain were more sensitive to pain. The effect size was slightly larger for the pain-physical activity relationship compared to the anticipated pain-physical activity relationship, suggesting that pain sensitivity is particularly influential when pain is actually experienced.

It is important to recognize that the results for pain sensitivity mirror those described above for pain anxiety. The likely overlap between the two measures is through hypervigilance. Patients who are sensitive to their pain may be displaying some type of hypervigilance, either through a cognitive mechanism or through central augmentation. Regardless of the mechanism, hypervigilance has been accepted as an important piece of the fear-avoidance model. It has been hypothesized that patients who have a fear of pain are hypervigilant for future occurrences of their pain and that patients who are hypervigilant for their pain are more likely to notice their pain.

Interestingly, despite the parallel relationship of physical activity with pain anxiety and pain sensitivity, these two variables were not correlated at a statistically significant level. This suggests that while there seems to be a shared mechanism of action, they may also be influencing physical activity in different ways. This is likely due to the fact that pain anxiety

and pain sensitivity overlap in a Venn diagram-type of relationship, where they share some common features but also differ in meaningful ways. From a pain sensitivity perspective, this may be due to the fact that some pain sensitivity reflects a natural difference in pain tolerance, as opposed to a difference in pain sensitivity resulting from hypervigilance. Similarly, there are many more mechanisms to the fear-avoidance relationship than hypersensitivity to pain, and therefore the portion of the fear-avoidance that is not related to pain sensitivity may represent those other elements of fear-avoidance (e.g., depression, catastrophizing, etc.). In summary, it is possible that pain sensitivity and fear-avoidance influence the positive and negative relationships of pain and anticipated pain with physical activity through multiple mechanisms.

Measurement of pain ratings in real time. A unique element of the current study was the assessment of pain ratings in real-time. This methodology was primarily advantageous but also highlighted a continued problem with obtaining pain ratings. The advantage pertains to one of the most significant challenges in using pain ratings in research, the variability *between* participants in pain ratings. As discussed previously, two patients with identical levels of pain may define their pain with entirely different numbers on the pain scale. In the present study, the repeated-measures data allowed for the pain ratings to be compared *within* subjects. Thus, the participants served as their own controls and the between-participant comparisons were based on each individual's pain-activity relationship, as opposed to the pain rating alone.

A problem with pain assessment in this study resulted from the lack of variability in pain ratings by some of the participants, considering that time-series analysis assesses how the variation in one variable relates to the variability in another. A subset of the participants

only used two or three numbers to describe their pain on the 11-point pain rating scale. The

impact of this lack of variability on the ability to identify meaningful relationships is visually

depicted in the graphs of two individual participants below (see Figures 3 and 4). In both

instances, the participant's amount of activity was approximately between 0 and 300 activity

counts per interval. However, the patient in Figure 3 used almost no variability in ratings,

primarily rating his or her current and anticipated pain as a 7 and occasionally an 8. The

patient in Figure 4 demonstrated a lot of variability, utilizing ratings 1 through 10 on the pain

rating scale. Meaningful associations between pain or anticipated pain and physical activity

are easily identified in Figure 4, but not in Figure 3.
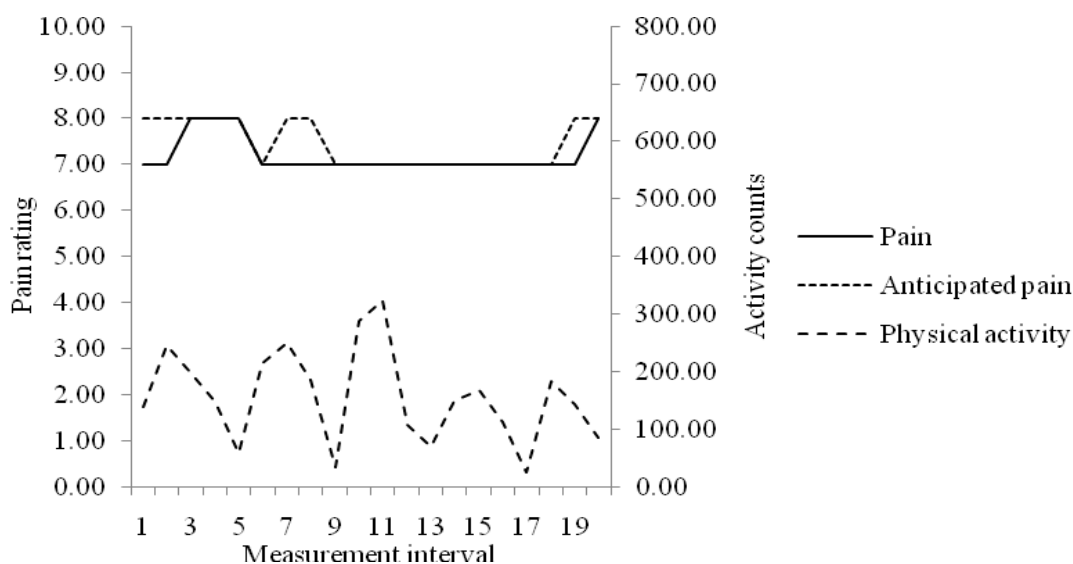
Figure 3. Graph of pain, anticipated pain, and physical activity for a patient who utilized 2

points on the pain and anticipated pain rating scales.
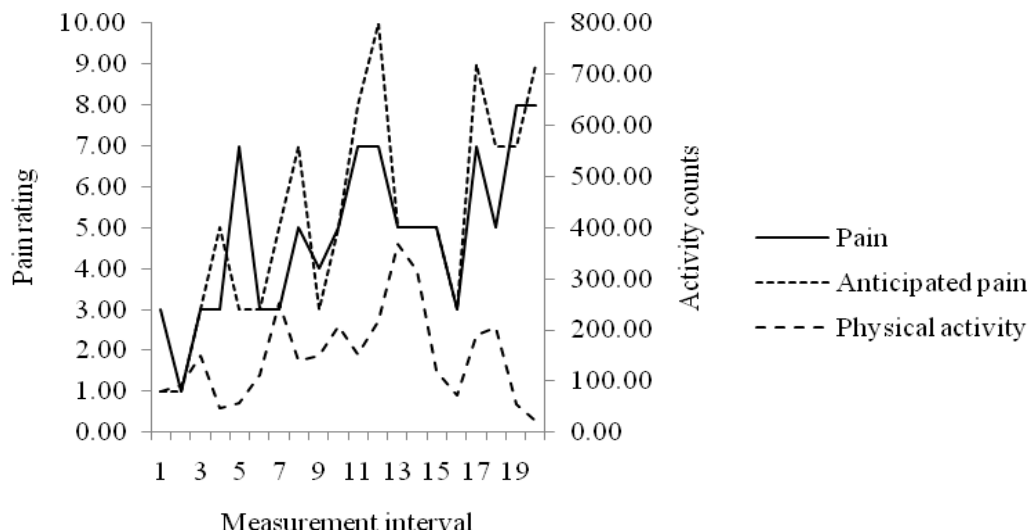
Figure 4. Graph of pain, anticipated pain, and physical activity for a patient who utilized 10 points on the pain and anticipated pain rating scales.

Pain Variables vs. Cognitive-behavioral Variables vs. Social Variables

The time series analysis assessing the relationships of current pain, representing the sensory experience, and anticipated pain, representing the patient's expectations about how this sensory experience would change over time, to physical activity served as a way to measure the ongoing changes in physical activity observed in this population. However, this was a simplistic view of the chronic pain experience, as the literature supports a variety of additional variables that explain how a patient's emotions, cognitions, and social environment can also contribute to the chronic pain experience and influence outcomes. These variables can broadly be categorized as pain variables, cognitive-behavioral variables, and social variables. For the present study, three variables were chosen to represent each of the aforementioned theoretical categories producing nine theoretically-based predictors. These nine predictors were then first analyzed to determine their individual contribution to

differences in physical activity between participants, and then were collapsed into their three models to determine the model's overall contribution to changes in physical activity.

Three predictors, each representing a different one of the three theoretical models, individually accounted for a statistically significant amount of the variance in physical activity: pain sensitivity from the pain model, fear of movement/(re)injury from the cognitive behavioral model, and solicitous significant other responses from the social model. Additionally, two demographic variables individually accounted for a statistically significant amount of the variance in physical activity: duration of pain and unemployment due to the pain problem. Consistent with our hypothesis, when collapsed into models, only the social model significantly predicted changes in physical activity. The results at each level – theoretically-based predictors, demographics variables, and theoretical models – are consistent with the existing literature. However, using OLS to simultaneously analyze cross-sectional and longitudinal panel data, objective measurement of physical activity as an outcome, and simultaneous analysis of the major predictors, this study also serves to clarify previous findings and identify new ways to think about the predictors of physical activity.

Results of analysis of research question 2. The theoretically-based predictors utilized in this study represented elements of the chronic pain experience that have been previously identified in the literature as statistically significantly associated with disability (e.g., Rudy et al., 2003; Turk & Okifuji, 1994; Alschuler et al., 2009; Geisser & Roth, 1999; Turner, Jensen, & Romano, 2000; Vlaeyen et al., 1995, 2000; Fordyce, 1976; Turk, 1996). However, it was unknown how these same predictors would relate to physical activity objectively measured, using the relatively new method afforded by actigraphy. The variables that accounted for a statistically significant amount of the variance in the analyses presented

here were pain sensitivity, pain anxiety, solicitous significant other responses, and two

demographic variables, being unemployed due to the pain problem and duration of pain.

Pain sensitivity was measured by identifying the level at which patients recognized a

stimulus as painful. The reasons for individual differences in pain sensitivity are uncertain,

but a theoretical framework suggests that pain sensitivity may at least in part be correlated

with one's attentional focus on painful stimuli, such as through the hypervigilance that is a

component of the fear-avoidance model (Leeuw et al., 2007), or the sensitivity to pain that

results from central sensitization or central augmentation (e.g., Melzack et al., 2001, 2004;

Geisser et al., 2008b; Giesecke et al., 2004; Gracely et al., 2002). Within this context, it

could be hypothesized high pain sensitivity would then interfere with physical activity

through an increased recognition of painful stimuli, followed by escape and avoidance

behavior. Thus, a patient who is more sensitive to pain would be more likely to notice his or

her sensations of pain and would seek to stop current pain from happening or future pain

from occurring. If the patient perceives physical activity as a cause of pain, it should follow

that a patient with high pain sensitivity engages in lower amounts of activity. This type of

relationship was observed through multiple analyses in this study, as supplemental analyses

of the time-series analysis data revealed that patients with escape-avoidance type behavior

could be identified through their pain sensitivity.

Given the potential relationship of pain sensitivity to the fear-avoidance model, as

well as the empirical support for this relationship identified through the time-series analysis

of the first research question, it is not surprising that scores on the fear of

movement/(re)injury measure utilized in this study, the TSK, were also a significant predictor

of activity. The results of this study showed that patients who said they are afraid to move

exhibited less physical activity than those who were not afraid to move. The clinical implications of this finding are important: in an effort to help patients maintain their level of activity, it is essential to help the patient differentiate pain signaling injury from harmless pain, so that the patient does not decrease his or her activity simply because of the experience of pain (Vlaeyen et al., 2000). There are a variety of good reasons for a patient to persist through harmless pain, including: (1) the pain may be due to deconditioning resulting from previous underutilization and not a signal of future harm, or (2) the negatives of being inactive (e.g., social withdrawal leading to depression) may significantly outweigh the negative sensory experience of pain that the patient would have to endure.

The third theoretically-based predictor that accounted for a statistically significant amount of variance in physical activity, significant others' solicitous responses to pain, suggests that in addition to the more classically conditioned fear-avoidance behavior, operant mechanisms are also contributory. Human behavior is influenced by others' reactions to the behavior, primarily through principles of reinforcement and punishment. The literature on disability has described the phenomenon where patients with overly attentive significant others are accidentally reinforced for being in pain (e.g., Fordyce, 1976). When a spouse, for example, devotes extra attention when the pain patient experiences pain, the spouse accidentally reinforces the patient's pain behavior. The results from the present study further support this powerful relationship: patients with more solicitous significant others engage in less physical activity. The assumption from this finding is that although the solicitous significant other is attempting to be helpful by encouraging the patient to rest, he or she is accidentally reinforcing the behavior of "doing nothing" by decreasing the number of unenjoyable or mandatory tasks the patient has to do (e.g., household chores) and increasing

the amount of attention the patient is getting (e.g., "How are you feeling today?"). This reinforcement may work covertly, as this may not be a conscious decision: patients commonly articulate a desire to return to normal activity, without recognizing that they may actually be enjoying their freedom from less enjoyable tasks. Additionally, significant others are likely acting with good intentions and do not recognize the impact of their behavior on the patient.

The two demographics variables that accounted for a statistically significant amount of the variance in physical activity allow for more specific inferences about differences in physical activity. First, patients who are not employed due to their pain problem engaged in less activity than those who were still employed or retired for reasons unrelated to their pain. This suggests that patients engage in a significant amount of their daily physical activity while working. This alone is not surprising, as the majority of the patients at the data collection clinic were employed in labor-intensive positions. Two possible explanations for these results arise: First, the ability to work may be associated with beliefs about one's ability to be active. For example, patients who are unable to work may see themselves as unable to engage in many other activities, causing them to further reduce their amount of activity. Second, all of the patients in this study who were not working were receiving disability payments. An operant mechanism similar to that of solicitous responses may be in play here, as it is generally perceived to be more rewarding to get paid not to work, as is the case in disability, than it is to get paid to work. Previous studies have similarly found a relationship between financial compensation and poor outcomes in chronic pain treatment (Rohling, Binder, & Langhinrichsen-Rohling, 1995). Thus, there may be an incentive to remain at a physical activity level that maintains disability status.

The second demographics variable that accounted for a statistically significant amount of the variance in physical activity suggested that patients who are in pain longer engage in less physical activity. A relationship between duration of pain and disability has been frequently identified in the literature (e.g., Swinkels-Meewisse et al., 2003). However, because pain duration is often assessed as a demographics variable, instead of as a primary research question, the literature is unclear on why this relationship exists. A number of explanations are possible. First, patients with longer pain duration are likely to have developed a variety of maintaining pain behaviors. Given the propensity of this population to engage in fear-avoidance behaviors, the duration of pain suggests that fear-avoidance behavior may be strengthened over time by repeated engagement in such behaviors. Second, neural reorganization is not instantaneous and, thus, is likely to be more prevalent among patients with longer pain duration. As was previously described, central sensitization can serve as maintaining factors of a chronic pain problem after the source of the original pain has healed. Third, duration of pain may be maintained by additional variables, such as a desire to remain on disability leave from work. Together, these possible explanations suggest that the influence of duration of pain on physical activity may be multidimensional in nature. Regardless of the mechanism of duration of pain's impact on disability, it appears that it is essential that patients get treatment in the earliest stages after onset of acute pain. This secondary prevention would be aimed at minimizing this risk factor for chronicity and thus for more significant disability.

It is also instructive to comment on variables that did not account for a significant amount of the variance in the model. Most notably, pain and anticipated pain did not account for a statistically significant amount of the variance in physical activity, further confirming

the observation made above, that when pain and anticipated pain are analyzed for the entire sample, they remain an unreliable measure in the prediction of physical activity. One could pose a number of hypothetical explanations for this finding, but it seems most likely that pain ratings are simply too subjective and too inconsistently applied between participants to be accurately used in group analyses (Turk & Melzack, 2001; Jensen & Karoly, 2001). Moreover, this emphasizes the biopsychosocial approach to pain problems, where pain is the sensory experience at the heart of the problem, but that it is the pain *problem* that is significant, not the pain itself.

It was also interesting that depression and catastrophizing did not account for a significant amount of the variance in physical activity, particularly considering the abundance of literature supporting a relationship between depression, catastrophizing, and poor pain outcomes. It is notable that depression approached significance ($p = 0.06$). However, the issue here may not be the relationship of depression, catastrophizing, and disability in general, but instead the ability to use depression and catastrophizing as predictors of activity specifically. For example, some theoretical models of depression suggest that depression originates from the lack of access to reinforcement and the increase in punishment (Lewinsohn, 1974; Fordyce, 1976). Thus, one might hypothesize that pain patients become depressed after their activity has decreased, and not before, because it would be the decrease in activity that would cause or worsen depressive symptoms. The fear-avoidance model addresses the directionality issue by describing depression as part of a cyclical model, whereby depression appears as an end result of the pain cycle but is also contributory to the continuation of the pain cycle (Vlaeyen et al., 1995). In other words, a patient may become depressed because of chronic pain, but being depressed may maintain

their chronic pain. An alternative explanation was that participants in this study were very polarized on their depression scores, but were more homogeneous in terms of activity. Thus, some very depressed patients and some patients who indicated very low levels of depression were somewhat similar in terms of activity.

Comprehensive interpretation of analysis of research question 2. Although the findings for the predictors individually are interesting in and of themselves, application of the results as a whole to the existing body of literature reveals an even more meaningful story. In the present study, sensitivity to pain was predictive of lower activity levels, suggesting that a central mechanism may be influencing patients' pain experiences. These findings are thus consistent with the literature regarding central augmentation which suggests that individuals with chronic pain problems have heightened sensitivity to painful stimuli, and with central sensitization which suggests that the brain reorganizes due to the persistent sensation of pain and, as a result, individuals with a long duration of pain continue to feel pain due to this reorganization, regardless of the presence of actual painful stimulation (Geisser et al., 2007b; Coderre, Katz, Vaccarino, & Melzack, 1993). Thus, it could be expected that individuals with longer duration of pain would thus be most influenced by the pain problem.

Another key finding of the present study was multiple levels of support for the fear-avoidance model. For example, as emerged from the time-series analysis, some of the patient responses to pain and anticipated pain were clearly examples of fear-avoidance responses. This finding is further bolstered by the TSK, a measure of fear of movement/(re)injury, accounting for a statistically significant amount of the variance in physical activity in the comprehensive analysis of all nine theoretically-based predictors. Whereas the time-series analysis could be used to explain how patients demonstrate fear-

avoidance behaviorally, the cognitions patients endorse on the TSK questionnaire could be used as evidence in support of the fear-avoidance patterns. At a time where support exists for cognitive (Thorn, 2004), behavioral (Vlaeyen et al., 2001), and mixed cognitive-behavioral (Otis, 2007) approaches to the treatment of chronic pain, this study demonstrates support for both cognitive and behavioral findings within one population simultaneously.

Although the findings related to solicitous spousal responses superficially appear to stand independent of the fear-avoidance model, it is important to consider the role of social messages in the interpretation of painful stimuli. If a patient already experiences pain, has a fear of experiencing more pain because it signals harm, and is now told by others to be inactive because of the pain, the patient is further reinforced for his or her belief that pain is harmful. This is consistent with Fordyce's (1976) belief that significant others influence pain problems by reinforcing pain behaviors and not reinforcing well behaviors.

Comparing models. By comparing a pain model to a cognitive behavioral model to a social model, the question to be answered by this study was "What is most powerful in determining one's level of activity: the sensory experience of pain, the way one thinks about pain and its effects, or the way others respond to pain?" The finding that significant others' responses account for a significant amount of the variance in physical activity suggests that the reinforcement and punishment of behavior trumps other mechanisms of behavior change. However, this is not to discount the cognitive element: the results do not exclude the possibility that it is the patients who say, "I do what I have to do," who tend to be most active; instead, the data of this study suggest that it is the patients who are told by their significant other, "You don't have to do that – I'll do it for you," who are the *least* active.

One of the most interesting elements to consider related to this finding is the fact that the majority of treatment approaches focus on the cognitive-behavioral elements – treating depression, catastrophizing, and fear of movement/(re)injury through cognitive, behavioral, and cognitive-behavioral approaches. However, the results here suggest that operant approaches, as well as approaches incorporating family members who influence pain behaviors, would target the aspects of chronic back pain that have the most effect on disability. Therefore, researchers developing new clinical interventions are advised to consider incorporating more interventions targeting the environments and social mechanisms that influence the patient's behavior.

The fact that the pain model did not account for a statistically significant amount of variance in physical activity provides further support for the idea that the role for this sensory experience is more likely in the establishment of pain behaviors rather than in the maintenance of pain behaviors once the patient is experiencing chronic pain. This interpretation supports observations that patients make associations between pain and specific stimuli or behaviors, and that the resulting learned behavioral responses are observed as disability (Turk & Flor, 1999; Vlaeyen & Linton, 2000).

The failure of the current study to find support for the composite cognitive behavioral model is more surprising, as other elements of this study strongly support the individual theoretically-based predictors representing the cognitive-behavioral model as accounting for a statistically significant amount of the variance in physical activity. Specifically, fear of movement/(re)injury was found to account for a significant amount of the variance in physical activity and the time-series analysis revealed behavioral patterns indicative of a fear-avoidance response. Additionally, some participants indicated high rates of depression. At

least two aspects of these findings deserve specific attention: First, it is important to recognize that the cognitive behavioral model primarily operates through classical conditioning (particularly in terms of fear-avoidance), whereas the social model utilizes operant reinforcement and punishment (Roelofs, Boissevain, Peters, deJong, & Vlaeyen, 2002). Thus, in the regression comparing the three composite models, a significant amount of the variance in physical activity accounted for by the composite social model, but not by the composite cognitive-behavioral model suggests that physical activity is most strongly affected by reinforcement and punishment relative to classical conditioning. Second, the cognitive-behavioral factors may simply fail to influence the amount of activity, but instead influence the type of activity. A recent study exploring the direction of the fear-avoidance – physical activity relationship similarly found a lack of relationship, in this case in either direction, suggesting that quantity of activity was not influenced by fear-avoidance (Leonhardt et al., 2009). Therefore, patients with high levels of fear-avoidance may qualitatively avoid certain movements (e.g., bending, twisting, lifting heavy objects), but may still engage in activity in general.

Variance explained by models. The OLS analyses utilized for research question 2 established that the predictors accounted for approximately 28% of the variance in physical activity. At first glance, 28% appears to be low. However, given that much of the chronic pain experience remains an "unsolved mystery," the ability to elucidate this amount of the variance in physical activity is a significant finding. Despite the 70% unexplained variance in physical activity, the knowledge that the identified variables impact 28% of the variance in physical activity has the potential to significantly impact clinical interventions. For example, this information could be used to further enhance treatments that seek to reduce the cognitive

and behavioral effects of a chronic pain problem (e.g., Otis, 2007; Thorn, 2004), increase the activity that has been inhibited by fear of pain (e.g., Vlaeyen et al., 2001), and seek to effect meaningful change in patients' pain levels.

It is imperative to understand that researchers are seeking to identify variables that will have *any meaningful impact* on symptoms, as opposed to attempting to identify a cure for the symptoms. Thus, information that can explain a substantial proportion of a problem (i.e., physical activity, in this case) is powerful information. The ability to target variables that result in small increases in activity or small decreases in pain may ultimately result in meaningful improvement for patients and, thus, identifying only some of the mechanisms behind patient differences may provide important guidance for treatment. For example, the chronic pain field has already come to understand that while the desire is to eliminate patients' pain, the reality is that relatively small improvements in pain – 27.9%, which is 2-3 points on a 10 point rating scale – are observed by patients as helping them feel "much improved" (Farrar et al., 2001). Thus, one does not need to understand everything that contributes to a patient's pain to be able to make an important impact through the development of pain management strategies. A similar statement could likely be made about physical activity, where patients may recognize a small amount of change in activity as meaningful. By targeting the variables that contributed to 28% of the variance in physical activity in this study, clinical researchers may be able to develop treatments that result in this type of meaningful change in activity.

Ultimately, the hope is that researchers can explain the entire, complex chronic pain phenomenon, but at present it appears acceptable to explain only part of the problem. However, given that the long-term goal is to explain this problem in its entirety, the

remaining question is how to account for the other 70% of the variance. Two possible

answers arise: First, there may be variables that were not assessed in this model that could

contribute to the model. Most notably we know very little about the meaning of physical

activity to these patients. It may not be important to them to engage in a quantity of physical

activity; more important may be in a certain quality of activity. Along these lines, studies

that have accounted for a greater amount of the variance in physical performance (i.e.,

clinical lifting tests) have included variables related to self-efficacy and global beliefs about

health status (Rudy et al., 2003). In the current study, all of the patients had chronic pain, but

no data were collected about their identified physical limitations. Thus, some participants

may have had an unlimited capacity for physical activity, while others may have had actual

physical limitations, again serving as a reminder that physical activity is only one component

of disability.

Second, the analysis conducted here identified common trends across participants for

the predictors and resulting variations in physical activity. The reality is that individual

patients may consistently respond differently to the antecedents analyzed in this study. For

example, two patients may present with depression and anxiety, but one patient limits his

activity due to depression, while the other limits her activity due to fear of re-injury, despite

the fact that both patients are depressed and have fear of re-injury.

The end result is that the findings presented here could contribute to the better

management of chronic pain. Without a cure, researchers are constantly in search of the

variables that account for the most significant amount of the variance in chronic pain

disability. Thus, the focus of the chronic pain treatment literature is on the management of

the symptoms of chronicity and not on curing the pain. For example, treatment manuals

written by Thorn (2005) and Otis (2007) are both predicated on the idea that the treatment

goal should be to better manage pain and not to look for a cure. The results of the current

study could serve as a guide to refining existing treatments or to developing new treatments.

The concept that chronic pain problems are best managed and are unlikely to be cured

is contrary to the biomedical model. As such, chronic pain presents a challenge to the

medical field, where patients seek answers and related cures. A recent review of pain

management suggested that the discipline could benefit from shifting from a cure-based

focus to a care-based focus (Crowley-Matoka, Saha, Dobscha, & Burgess, 2009) in an effort

to more appropriately address chronic pain problems.

Physical Activity vs. Perceived Disability vs. Physical Ability

One of the unique elements of this study was the use of physical activity as a

disability measure. As detailed in the Introduction section, studies of chronic pain patients

most commonly use self-report of perceived disability as the basis for disability research

(Jacob & Kerns, 2001). Undoubtedly, physical activity and perceived disability are different

constructs. Hence, it is also safe to suggest that physical activity represents a component of

disability in general and likely is one of many factors an individual considers when

describing his or her level of disability.

The use of physical activity as the outcome measure in the present study allows for a

variety of new and unique conclusions to be drawn. First, measuring physical activity

instead of self-reported perceived disability as an outcome measure has the potential to be

helpful in improving clinical outcomes. The literature suggests that common problems in the

chronic pain population, such as deconditioning and reduced range of motion, are affected by

decreased physical activity (Vlaeyen et al., 1995a). As a result, exercise-based treatment programs have been developed and validated, with an increase in physical activity as a targeted outcome (Verbunt et al., 2003b). Clarifying the mechanisms underlying individual differences in physical activity could serve to strengthen these activity-oriented interventions. Second, assessing physical activity allowed for the use of actigraphy, thus inserting an objective outcome into a field of study primarily dominated by the subjective self-report of perceived disability or the objective clinical tests which may nevertheless not necessarily be applicable to daily life.

Despite the advantages of measuring physical activity objectively via actigraphy, in order to relate this study's findings to the existing literature, this study was designed to compare analyses using actigraphy with analyses using the self-report measures more common in traditional studies of disability. To gain preliminary information about similarities and differences in results based on type of disability measure, multiple regression analyses were run to assess the contribution of the theoretical models to each of the measures of disability. This secondary analysis was limited in power by the study sample size but provided some interesting information about the disability measures. Consistent with the results of the OLS analysis, the social model accounted for a significant amount of the variance in physical activity, while the other two models did not. This supports the other analyses reported above regarding the relative power of social factors versus cognitive behavioral or pain variables.

When perceived disability was used as the dependent variable in the analysis, a significant amount of the variance was accounted for by cognitive-behavioral variables, but not by pain or social variables. This is consistent with the general assumptions underlying

the construct of perceived disability. It is common for measures of perceived disability to be rooted heavily in psychosocial variables and, specifically, the impact that the individual's condition has on his or her life (Bradley & McKendree-Smith, 2001; DeGood & Tait, 2001; Romano & Schmaling, 2001; Jacob & Kerns, 2001). Commonly, this includes such elements as feeling down about one's situation (as in depression), worrying about the severity of the pain problem (as in catastrophizing), and fearing further injury to the body (as in fear of movement/(re)injury).

Last, when the six-minute walk was used as the dependent variables in the analysis, none of the models accounted for a significant amount of the variance. This was moderately surprising, as evidence does exist for a relationship between the six-minute walk and the measure of perceived disability used here, the RMDQ (Lee, Simmonds, Novy, & Jones, 2001). However, the Lee et al. (2001) study explored the relationship of six-minute walk results to perceived disability whereas the present study examined the relative variance that the three explanatory models accounted for in disability when disability was measured by three different methods, resulting in an entirely different analysis.

The most interesting result to emerge from this set of multiple regressions was that the predictors of physical activity identified through this study were somewhat different from the predictors of perceived disability identified in previous studies. Specifically, nine predictors were included in the present study due to their previously identified relationship with perceived disability, but only three were found to be related to physical activity in the present study. Although the results of the current study do not allow for specific conclusions to be drawn about this discrepancy, multiple possible explanations arise: It appears that when a chronic low back pain patient's mood declines, he or she feels more disabled. However,

this may not impact the patient's actual amount of activity. Thus, a patient either feels disabled for reasons other than quantity of activity or the patient is depressed about a perceived decrease in activity, although this change in activity may be a misperception. Some of the reasons a patient may feel disabled could be the change in type of activity (instead of the quantity of activity) or the effort it takes or discomfort that is present when engaging in activity. Alternatively, if the patient is misperceiving his or her level of activity, it is likely that the patient is catastrophizing by exaggerating the amount that activity has changed. This could be a target of clinical intervention, particularly as it relates to cognitive distortions that a patient may make.

Limitations

Although the present study was constructed with a specific focus on the design flaws of previous studies of chronic low back pain disability, at least two limitations were present. Consistent with most clinical research, the first limitation was the difficulty in attaining a large sample size. The population recruited for the present study was primarily patients engaged in an intensive rehabilitation program with a large number of clinical visits. For some patients, participating in a one-week research study with an additional clinic visit was too much of an additional burden. Additionally, the patients from the potential participant pool were often complex patients with multiple medical conditions. In an effort to obtain meaningful results specific to chronic low back pain patients, numerous patients were excluded from the study due to stringent inclusion and exclusion criteria. The result was a small sample size, causing limitations in the available analyses and difficulty identifying the variables that accounted for a statistically significant amount of the variance in measures of

disability. However, the negative effects of this small sample size were minimized by the use of the time series and OLS regression analyses to analyze the primary research questions. Both techniques were sufficiently powered with the current sample size and repeated measurement, as their power was dependent on the number of observations, instead of the number of participants.

A second limitation was an inability to compare the physical activity data to a variety of important contextual variables. For example, an important component of disability is the effect that a change in functioning has on the individual. To assess this change in functioning, the ideal study would be longitudinal, assessing change in activity over time. An additional important component of disability is the effect that a change in type of activity has on the individual. Similarly, these data would need to be collected longitudinally. Thus, by assessing cross-sectional data, the present study was limited in its ability to identify the effect of change in activity on the individual.

Future Directions

The present study provided unique information through new methodology and measurement. However, with the unique nature of the study comes a variety of new research questions and angles for future study, including descriptive studies, clinical studies, and studies using actigraphy.

Although the present study is descriptive of a chronic low back pain population, it is actually particularly valuable for the continued development of appropriate clinical interventions. The chronic low back pain population is complex to understand and, thus, is

complex to treat. As clinicians better understand their population, they will be better equipped to target the specific problems afflicting their patients.

Thus, future research should go in two directions, basic and applied. First, the study presented here is far from the end of basic research on chronic low back pain patients. The present study was consistent with the extant literature in some ways but conflicted with it in others. Equally important, it also added more questions for future studies to explore. For example, researchers should consider ways to unobtrusively collect contextual information to supplement the unobtrusive physical activity measurement afforded by actigraphy, so as to collect information relevant to disability (e.g., a combination of activity and changes in valued activity) instead of simply activity.

The second area for expansion is applied clinical research. By extrapolating from the findings presented here, clinicians have an opportunity to refine their assessments and interventions. Specifically, the present study helped to more accurately describe chronic low back pain patients' regular activity patterns. Although the results generally support the well-established fear-avoidance model, they also suggest that at least some patients may display behavior that is directly opposite to the fear-avoidance model, by pushing through pain. Clinically, one might say that these patients are susceptible to "overdoing" activity. The results suggest that if clinicians can accurately assess patients' response styles to pain and anticipated pain, they can more appropriately address the patient's pain problem.

Finally, the present study was one of only a few studies on low back pain patients using actigraphy and, perhaps, was the most detailed of that group. Actigraphy provides a unique insight into patients' lives, most importantly by accurately and unobtrusively monitoring what the patient is actually doing in his or her life. One particularly interesting

application of actigraphy is measurement of treatment outcome. In the larger study of which the present study was a segment, patients repeated data collection to assess changes in activity patterns following an intensive multidisciplinary treatment program. The resulting data could be analyzed to assess both activity patterns and the associated predictors, to better identify the mechanisms of change from the treatment program.

Considering the complex nature of chronic low back pain, it appears likely that the potential will always exist for future research. Ideally, subsequent studies can utilize the findings of previous research to answer increasingly specific questions about chronic pain problems. This strategy was modeled in the present study, whereby the existing literature on predictors of disability was utilized as a foundation for the assessment of physical activity. Future research could build upon the current study by expanding on the use of actigraphy to conduct, for example, longitudinal studies of change in activity. The results of the present study suggest that physical activity remains an important area of study for the chronic low back pain population but again showed that physical activity is a complex area of study that deserves further attention by researchers in the future.

Summary

This study is the first study to comprehensively assess physical activity and a biopsychosocial set of predictors of physical activity using continuous ambulatory monitoring. Assessment of chronic low back pain patients revealed that physical activity is predicted by pain sensitivity, fear of pain, significant others' solicitous responses to pain, duration of pain, and unemployment due to pain. Additionally, patients' changes in physical activity were correlated, either consistently positively or consistently negatively, with

changes in pain and anticipated pain. These findings serve to further explain physical activity in the chronic low back pain patient and expand upon the existing literature by assessing physical activity in real-time. By identifying some mechanisms that appear to affect engagement in activity, the results of this study ultimately could also serve to guide the development of interventions for physical activity in chronic low back pain patients.

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APPENDICES

Appendix A

Low Back Pain Study   Subject_____
Psychologist Screening Form   Date_____

Information about the study:

Researchers at the Spine Program are conducting a study on people with chronic low back pain that you might be interested in. The study is being done to try to better understand how people with back pain are experiencing pain throughout their daily routines and what their physical activity levels are like. They are also trying to determine how the treatment provided in the Spine Program affects pain and physical activity. If you are interested, you would participate in an hour lab visit in this building consisting of a few performance assessments and questionnaires and a home data collection period in which you would wear a physical activity monitor continuously for five days before treatment at the Spine Program. Then you'd do the same (lab visit + home data collection) after receiving treatment in the Spine Program. Compensation for participation in the entire protocol is $120. If you may be interested, I can give a member of the study team your phone number to contact you to let you know more details about the study.

Inclusion criteria:

Yes   No

☐   ☐ Between ages of 30 – 55; RECORD AGE _____

☐   ☐ Reports low back pain for 3 months or more

☐   ☐ Walks without a cane or walker

Exclusion criteria:

Yes   No

☐   ☐ Has another condition(s) that interferes with gait or is significantly disabling

         (e.g. stroke, peripheral neuropathy, Parkinson's Disease, Multiple Sclerosis, Lupus)

         RECORD CONDITION(S)_____

☐   ☐ Has a physical disability that prohibits physical exercise

☐   ☐ Has dementia or psychotic features detected on evaluation

☐   ☐ Is currently receiving PT or OT

If all gray boxes are checked and subject is interested, please provide a phone number below where they can be contacted by a member of the study team:

PHONE NUMBER _____

Appendix B
Demographics Questionnaire

Subject ID: _____   Date: ___ / ___ / ___
Demographics

---

1. Age (years)   _____

2. Sex   ☐ ^{0} Male
                            ☐ ^{1} Female

3. Dominant Hand   ☐ ^{0} Right
                            ☐ ^{1} Left

4. Marital Status   ☐ ^{0} Single
                            ☐ ^{1} Married
                            ☐ ^{2} Separated
                            ☐ ^{3} Divorced
                            ☐ ^{4} Widowed

5. Ethnicity   ☐ $_0$ Non-Hispanic or Latino
                            ☐ $_1$ Hispanic or Latino

6. Race   ☐ ^{0} American Indian/Alaskan Native
                            ☐ ^{1} Asian
                            ☐ ^{2} Native Hawaiian or Pacific Islander
                            ☐ ^{3} Black or African American
                            ☐ ^{4} White
                            ☐ ^{5} More than one race
                            ☐ ^{6} Unknown or not reported

**7. How many years did you
go to school?**   _____

8. If less than 12 years, did   ☐ ^{0} No
you get your GED?   ☐ ^{1} Yes

9. Employment   ☐ ^{0} Working full-time
                            ☐ ^{1} Working part-time
                            ☐ ^{2} Homemaker
                            ☐ ^{3} Not working due to pain
                            ☐ ^{4} Not working due to other reasons (e.g. retired)

10. Do you receive   ☐ ^{0} No
disability payments?   ☐ ^{1} Yes

11. Are you involved in ☐ ^{0} No
litigation related to your ☐ ^{1} Yes
pain?

**12. How many months have
you been in pain?**   _____

Appendix C
Center for Epidemiological Studies Depression Scale

MOOD INVENTORY

Below is a list of the ways you might have felt or behaved. Please circle the answer that best describes how often you have felt or behaved this way DURING THE PAST WEEK.

- 0 - Rarely or None of the Time = less than 1 day
- 1 - Some or Little of the Time = 1-2 days
- 2 - Occasionally or a Moderate Amount of Time = 3-4 days
- 3 - Most or All of the Time = 5-7 days

	0 Rarely/ None of the Time	1 Some or Little of the Time	2 Occasion Moderate the Time	3 Most/ All of the Time
a. I was bothered by things that usually don't bother me.	0	1	2	3
b. I did not feel like eating. My appetite was poor.	0	1	2	3
c. I felt I could not shake off the blues even with help from family or friends	0	1	2	3
d. I felt that I was just as good as other people.	0	1	2	3
e. I had trouble keeping my mind on what I was doing.	0	1	2	3
f. I felt depressed	0	1	2	3
g. I felt that everything I did was an effort.	0	1	2	3
h. I felt hopeful about the future.	0	1	2	3
i. I thought my life had been a failure.	0	1	2	3
j. I felt fearful.	0	1	2	3
k. My sleep was restless.	0	1	2	3
l. I was happy.	0	1	2	3
m. I talked less than usual.	0	1	2	3
n. I felt lonely.	0	1	2	3
o. People were unfriendly.	0	1	2	3
p. I enjoyed life.	0	1	2	3
q. I had crying spells.	0	1	2	3
r. I felt sad.	0	1	2	3
s. I felt that people dislike me.	0	1	2	3
t. I could not "get going"	0	1	2	3

CES-D Scoring instructions

1. Assignment of values:
   a. Scores of 0, 1, 2, and 3, as indicated in instrument.
   b. Four items are reversed scored: 4, 8, 12, 16

2. Compute total:
   a. Add the values for each of the 20 items.
   b. The resulting score should range between 0 and 60.
   c. Do not compute a total if there is more than one answer missing.

3. Meaning of scores:
   a. High scores on the CES-D indicate high levels of distress.
   b. ≥ 16 suggests a clinically significant level of psychological distress, but does not necessarily mean that the participant has a clinical diagnosis of depression.

Appendix D
Pain Catastrophizing Scale

Name: _____   Date: _____

PAIN COGNITIONS SCALE (PCS)

We are interested in looking at the relationship between thoughts and pain. Please indicate the degree to which you have experienced each of the following thoughts or feelings when experiencing pain by circling a number under each statement.

When I feel pain...

1. I worry all the time about whether the pain will end.

        0   1   2   3   4

  Not at all   All the time

2. I feel I can't go on.

        0   1   2   3   4

  Not at all   All the time

3. It's terrible and I think it's never going to get any better.

        0   1   2   3   4

  Not at all   All the time

4. It's awful and I feel that it overwhelms me.

        0   1   2   3   4

  Not at all   All the time

5. I feel I can't stand it anymore.

        0   1   2   3   4

  Not at all   All the time

6. I become afraid that the pain may get worse.

        0   1   2   3   4

  Not at all   All the time

7. I think of other painful experiences.

        0   1   2   3   4

  Not at all   All the time

8. I anxiously want the pain to go away.

0	1	2	3	4

Not at all   All the time

1. I can't seem to keep it out of my mind.

0	1	2	3	4

Not at all   All the time

2. I keep thinking about how much it hurts.

0	1	2	3	4

Not at all   All the time

3. I keep thinking about how badly I want the pain to stop.

0	1	2	3	4

Not at all   All the time

4. There is nothing I can do to reduce the intensity of the pain.

0	1	2	3	4

Not at all   All the time

5. I wonder whether something serious may happen.

0	1	2	3	4

Not at all   All the time

Pain Catastrophizing Scale Scoring Information

Sullivan, Bishop & Pivik, 1995

Name:	Age:	Gender:	Date:
-----------------------------	----------	☐ Male ☐ Female	----------------------

Rumination	Questions:	Score
	8	
Mean 10.1	9	
Standard Deviation 4.3	10	
	11	
	Total	
Magnification		
	6	
Mean 4.8	7	
Standard Deviation 2.8	13	
	Total	
Helplessness		
	1	
	2	
Mean 13.3	3	
Standard Deviation 4.3	4	
	5	
	12	
	Total	
OVERALL	**TOTAL**	
Total Mean 28.2		
Total Standard Deviation 12.3		

* Values are drawn from Sullivan et al., 1998

THE TAMPA SCALE (v. 2)
KORI, MILLER & TODD

NAME: _____ DATE: _____/_____/_____
month   day   year

DATE OF BIRTH: _____/_____/_____   MARRIED? ___Y   ___N   SEX: ___M   ___F

LOCATION OF PAIN: _____ EMPLOYED? ___Y   ___N

HOW LONG HAS THIS PAIN EXISTED? NUMBER OF _____YEARS   _____MONTHS

In these days of high-tech medicine, one of the most important sources of information about you is often missing from your medical records: your <u>own</u> feelings or intuitions about what is happening with your body. We hope that the following information will help fill that gap.

Please answer the following questions according to the scale on the right. Please answer according to your true feelings, not according to what others think you should believe. This is not a test of medical knowledge; we want to know how you see it. Circle the number next to each question that best corresponds to how you feel.

Please answer all these questions by yourself.
We want to know how <u>you</u> feel, not someone else.

	STRONGLY DISAGREE	SOMEWHAT DISAGREE	SOMEWHAT AGREE	STRONGLY AGREE
1. People aren't taking my medical condition seriously enough	1	2	3	4
2. My body is telling me I have something dangerously wrong	1	2	3	4
3. My accident has put my body at risk for the rest of my life	1	2	3	4
4. I am afraid that I might injure myself accidentally	1	2	3	4
5. If I were to try to overcome it, my pain would increase	1	2	3	4
6. Simply being careful that I do not make any unnecessary movements is the safest thing I can do to prevent my pain from worsening	1	2	3	4
7. I wouldn't have this much pain if there weren't something potentially dangerous going on in my body.	1	2	3	4
8. Pain always means I have injured my body.	1	2	3	4
9. Pain lets me know when to stop exercising so that I don't injure myself.	1	2	3	4
10. It's really not safe for a person with a condition like mine to be physically active.	1	2	3	4
11. I'm afraid that I might injure myself if I exercise	1	2	3	4
12. I can't do all the things normal people do because it's too easy for me to get injured	1	2	3	4
13. No one should have to exercise when she/he is in pain	1	2	3	4

THANK YOU FOR TAKING THE TIME TO ANSWER THISE QUESTIONS ABOUT YOU!

Appendix F
Multidimensional Pain Inventory

MULTIDIMENSIONAL PAIN INVENTORY

Name: _____ Date: _____

Instructions

An important part of your evaluation includes examination of pain from your perspective because you know your pain better than anyone else. The following questions are designed to help us learn more about your pain and how it affects your life. Under each question is a scale to mark your answer. Read each question carefully and then circle a number on the scale under that question to indicate how that specific question applies to you. An example may help you to better understand how you should answer these questions.

Example

How nervous are you when you ride in a car when traffic is heavy?

        0   1   2   3   4   5   6
    Not at all   Extremely
    Nervous   Nervous

If you are not at all nervous is a car in heavy traffic, you would want to circle the number 0. If you are very nervous when riding in a car in heavy traffic, you would want to circle the number 6. Lower numbers would be used for less nervousness, and higher numbers for more nervousness.

BEFORE YOU BEGIN, PLEASE ANSWER 2 PRE-EVALUATION QUESTIONS BELOW:

1. Some of the questions in this questionnaire refer to your "significant other". A significant other is *a person with whom you feel the closest*. This includes *anyone* that you relate to on a regular or infrequent basis. It is very important that you identify someone as your "significant other." Please indicate who your significant other is (check one):

❑ Spouse   ❑ Partner/companion   ❑ Housemate/roomate

❑ Friend   ❑ Neighbor   ❑ Parent/child/other relative

Other (please describe):

2. Do you currently live with this person?   ❑ YES   ❑ NO

When you answer questions in the following pages about your "significant other," always respond in reference to the specific person you just indicated.

Section I

1. Rate the level of your pain at the <u>present moment</u>.

          0   1   2   3   4   5   6
    No pain   Very intense pain

2. In general, how much does your pain interfere with your day-to-day activities.

          0   1   2   3   4   5   6
    No interference   Extreme interference

3. Since the time you pain began, how much has your pain changed your ability to work?
    (____ Check here, if you have retired for reasons other than your pain).

          0   1   2   3   4   5   6
    No change   Extreme change

4. How much has your pain changed the amount of satisfaction or enjoyment you get from
    taking part in social and recreation activities?

          0   1   2   3   4   5   6
    No change   Extreme change

5. How supportive or helpful is your spouse (significant other) to you in relation to your
    pain?

          0   1   2   3   4   5   6
    Not at all   Extremely
    supportive   supportive

6. Rate your overall mood during the <u>past week</u>.

          0   1   2   3   4   5   6
    Extremely low   Extremely high

7. How much has your pain interfered with your ability to get enough sleep?

          0   1   2   3   4   5   6
    No interference   Extreme interference

8. On the average, how severe has your pain been during the <u>last week</u>?

          0   1   2   3   4   5   6
    Not at all   Extremely
    severe   severe

9. How able are you to predict when your pain will start, get better, or get worse?

      0   1   2   3   4   5   6
Not at all   Very able
able to predict   to predict

10. How much has your pain changed your ability to take part in recreational and other social activities?

      0   1   2   3   4   5   6
No change   Extreme change

11. How much do you limit your activities in order to keep your pain from getting worse?

      0   1   2   3   4   5   6
Not at all   Very much

12. How much has your pain changed the amount of satisfaction or enjoyment you get from family related activities?

      0   1   2   3   4   5   6
No change   Extreme change

13. How worried is your spouse (significant other) about you because of your pain?

      0   1   2   3   4   5   6
Not at all   Extremely
worried   worried

14. During the <u>past week</u> how much control do you feel that you have had over your life?

      0   1   2   3   4   5   6
No control   Extreme control

15. On an average day, how much does your pain vary (increase or decrease)?

      0   1   2   3   4   5   6
Remains   Changes
the same   a lot

16. How much suffering do you experience because of your pain?

      0   1   2   3   4   5   6
No suffering   Extreme suffering

17.   How often are you able to do something that helps to reduce your pain?

       0   1   2   3   4   5   6
Never   Very often

18.   How much has your pain changed your relationship with your spouse, family, or significant other?

       0   1   2   3   4   5   6
No change   Extreme change

19.   How much has your pain changed the amount of satisfaction or enjoyment you get from work?
(___ Check here, if you are not presently working).

       0   1   2   3   4   5   6
No change   Extreme change

20.   How attentive is your spouse (significant other) to you because of your pain?

       0   1   2   3   4   5   6
Not at all   Extremely
Attentive   attentive

21.   During the <u>past week</u> how much do you feel that you've been able to deal with your problems?

       0   1   2   3   4   5   6
Not at all   Extremely well

22.   How much control do you feel that you have over your pain?

       0   1   2   3   4   5   6
No control   A great deal
at all   of control

23.   How much has your pain changed your ability to do household chores?

       0   1   2   3   4   5   6
No change   Extreme change

24.   During the <u>past week</u>, how successful were you in coping with stressful situations in your life?

       0   1   2   3   4   5   6
Not at all   Extremely
successful   successful

25.   How much has your pain interfered with your ability to plan activities?

        0   1   2   3   4   5   6
No change   Extreme change

26.   During the <u>past week</u> how irritable have you been?

        0   1   2   3   4   5   6
Not at all   Extremely
irritable   irritable

27.   How much has your pain changed or interfered in your friendships with people other than your family?

        0   1   2   3   4   5   6
No change   Extreme change

28.   During the <u>past week</u> how tense or anxious have you been?

        0   1   2   3   4   5   6
Not at all   Extremely
tense/anxious   tense/anxious

Section II

In this section, we are interested in knowing how your significant other (this refers to the person you indicated above) responds to you when he or she knows that you are in pain. On the scale listed below each question, <u>circle a number</u> to indicate <u>how often</u> your significant other responds to you in that particular way when you are in pain. Please answer all of the 14 questions.

1.   Ignores me.

        0   1   2   3   4   5   6
Never   Very often

2.   Asks me what he/she can do to help.

        0   1   2   3   4   5   6
Never   Very often

3.   Reads to me.

        0   1   2   3   4   5   6
Never   Very often

4.   Gets irritated with me.

        0   1   2   3   4   5   6
Never   Very often

5.   Takes over my jobs or duties.

        0   1   2   3   4   5   6
Never   Very often

6.   Talks to me about something to take my mind off the pain.

        0   1   2   3   4   5   6
Never   Very often

7.   Gets frustrated with me.

        0   1   2   3   4   5   6
Never   Very often

8.   Tries to get me to rest.

        0   1   2   3   4   5   6
Never   Very often

9.   Tries to involve me in some activity.

        0   1   2   3   4   5   6
Never   Very often

10.   Gets angry with me.

        0   1   2   3   4   5   6
Never   Very often

11.   Gets me pain medication.

        0   1   2   3   4   5   6
Never   Very often

12.   Encourages me to work on a hobby.

        0   1   2   3   4   5   6
Never   Very often

13.   Gets me something to eat or drink.

       0   1   2   3   4   5   6
Never   Very often

14.   Turns on the TV to take my mind off the pain.

       0   1   2   3   4   5   6
Never   Very often

Section III

Listed below are 19 daily activities. Please indicate <u>how often</u> you do each of these by <u>circling a number</u> on the scale listed below each activity. Please complete all questions.

1.   Wash dishes.

       0   1   2   3   4   5   6
Never   Very often

2.   Mow the lawn. (___ Check here, if you do not have a lawn to mow).

       0   1   2   3   4   5   6
Never   Very often

3.   Go out to eat.

       0   1   2   3   4   5   6
Never   Very often

4.   Play cards or other games.

       0   1   2   3   4   5   6
Never   Very often

5.   Go grocery shopping.

       0   1   2   3   4   5   6
Never   Very often

6.   Work in the garden (___ Check here, if you do not have a garden).

       0   1   2   3   4   5   6
Never   Very often

7.   Go to a movie.

          0   1   2   3   4   5   6
       Never   Very often

8.   Visit friends.

          0   1   2   3   4   5   6
       Never   Very often

9.   Help with the house cleaning.

          0   1   2   3   4   5   6
       Never   Very often

10.   Work on the car (___ Check here, if you do not have a car).

          0   1   2   3   4   5   6
       Never   Very often

11.   Take a ride in a car or bus.

          0   1   2   3   4   5   6
       Never   Very often

12.   Visit relatives (___ Check here, if you do not have relatives within 100 miles).

          0   1   2   3   4   5   6
       Never   Very often

13.   Prepare a meal.

          0   1   2   3   4   5   6
       Never   Very often

14.   Wash the car (___ Check here, if you do not have a car).

          0   1   2   3   4   5   6
       Never   Very often

15.   Take a trip.

          0   1   2   3   4   5   6
       Never   Very often

16.   Go to a park or beach.

               0   1   2   3   4   5   6
Never   Very often

17.   Do the laundry.

               0   1   2   3   4   5   6
     Never   Very often

18.   Work on a needed household repair.

               0   1   2   3   4   5   6
     Never   Very often

19.   Engage in sexual activity.

               0   1   2   3   4   5   6
     Never   Very often

WEST HAVEN-YALE MULTIDIMENSIONAL PAIN INVENTORY

Kerns, Turk & Rudy (1985)

SCORING GUIDE

Part I

Interference: (Question 2+3+4+8+9+13+14+17+19)/9
Support: (Question 5+10+15)/3
Pain Severity: (Question 1+7+12)/3
Life-Control: (Question 11+16)/2
Affective Distress: ((6-Question 6)+18+20)/3

Part II

Negative Responses: (Question 1+4+7+10)/4
Solicitous Responses: (Question 2+5+8+11+13+14)/6
Distracting Responses: (Question 3+6+9+12)/4

Part III

Household Chores: (Question 1+5+9+13+17)/5
Outdoor Work: (Question 2+6+10+14+18)/5
Activities Away from Home: (Question 3+7+11+15)/4
Social Activities: (Question 4+8+12+16)/4
General Activity: (Sum of all questions in Part III)/18

*** To account for sporadic missing data, sums should be divided by the number of non-missing items. Any scale with more than 25% of its items missing should be considered missing.

Appendix G
Low Back Pain Testing Data Sheet

Pressure Sensitivity Test

I will place the stimulator on your arm, and gradually increase the amount of pressure. Tell me when the sensation you feel just first starts to become painful.

Stimulate deltoid muscle, gradually increasing the pressure (1 kg/second).

Pressure Thresholds

1. _____

2. _____

3. _____

Heart Rate

Predicted Maximum Heart Rate (220 – age) = _____

80% of Max HR _____

Six Minute Walk Test

Subject will walk for a total of 6 minutes. Explain to the subject that they will walk as far as they can in 6 minutes. Be sure to tell them that during this time they may stop and rest. The time will run continuously even if the subject stops to rest. The subject should walk at a pace in which they could talk with you if you asked them (not extremely short of breath). Also inform the subject that they should maintain their pace all along the walk. The distance the subject walks in 6 minutes will be recorded.

Before we begin your next task, please rate your pain and fatigue by pointing to the number that tells how much pain/fatigue you have right now.

0	1	2	3	4	5	6	7	8	9	10
No Pain										Pain as bad as you can imagine

0	1	2	3	4	5	6	7	8	9	10
No Fatigue										Fatigue as bad as you can imagine

Low Back Pain Study **Subject ID**_____
 Testing Data Sheet **Date**_____
  Subject's age_____

Now I'd like you to walk all the way down to the taped line, turn around, and walk back, and continue walking back and for six minutes if you can. Walk at your own pace. Ready? Go.

Time (minutes and seconds) taken during each loop (a loop is one rotation of the walkway)

Example: loop 1. 1:23	
1.	12.
2.	13.
3.	14.
4.	15.
5.	16.
6.	17.
7.	18.
8.	19.
9.	20.
10.	21.
11.	22.

Did the subject take a break during the test?
☐ Yes   ☐ No

Did the subject lose balance or become unsteady during the test?

☐ *Yes*   ☐ *No*

Total distance covered in feet _____

After the test:
Please rate your pain and fatigue by pointing to the number that tells how much pain/fatigue you have right now.

0	1	2	3	4	5	6	7	8	9	10
No Pain										Pain as bad as you can imagine

0	1	2	3	4	5	6	7	8	9	10
No Fatigue										Fatigue as bad as you can imagine

Using this scale (show the RPE)*, please indicate how hard you feel that you were working during the walking task.*

Subject's reported RPE (scale next page)_____

Borg RPE Scale

6	No exertion at all
7	Extremely light
8	
9	Very light
10	
11	Light
12	
13	Somewhat hard
14	
15	Hard (heavy)
16	
17	Very hard
18	
19	Extremely hard
20	Maximal exertion

The Roland-Morris Low Back Pain and Disability Questionnaire

Patient name: _____ File #_____ Date:_____

Please read instructions: When your back hurts, you may find it difficult to do some of the things you normally do. Mark only the sentences that describe you today.

☐ I stay at home most of the time because of my back.
☐ I change position frequently to try to get my back comfortable.
☐ I walk more slowly than usual because of my back.
☐ Because of my back, I am not doing any jobs that I usually do around the house.
☐ Because of my back, I use a handrail to get upstairs.
☐ Because of my back, I lie down to rest more often.
☐ Because of my back, I have to hold on to something to get out of an easy chair.
☐ Because of my back, I try to get other people to do things for me.
☐ I get dressed more slowly than usual because of my back.
☐ I only stand up for short periods of time because of my back.
☐ Because of my back, I try not to bend or kneel down.
☐ I find it difficult to get out of a chair because of my back.
☐ My back is painful almost all of the time.
☐ I find it difficult to turn over in bed because of my back.
☐ My appetite is not very good because of my back.
☐ I have trouble putting on my sock (or stockings) because of the pain in my back.
☐ I can only walk short distances because of my back pain.
☐ I sleep less well because of my back.
☐ Because of my back pain, I get dressed with the help of someone else.
☐ I sit down for most of the day because of my back.
☐ I avoid heavy jobs around the house because of my back.
☐ Because of back pain, I am more irritable and bad tempered with people than usual.
☐ Because of my back, I go upstairs more slowly than usual.
☐ I stay in bed most of the time because of my back.

Instructions:

1. The patient is instructed to put a mark next to each appropriate statement.

2. The total number of marked statements are added by the clinician. Unlike the authors of the Oswestry Disability Questionnaire, Roland and Morris did not provide descriptions of the varying degrees of disability (e.g., 40%-60% is severe disability).

3. Clinical improvement over time can be graded based on the analysis of serial questionnaire scores. If, for example, at the beginning of treatment, a patient's score was 12 and, at the conclusion of treatment, her score was 2 (10 points of improvement), we would calculate an 83% (10/12 x 100) improvement.

ACTI-SCORE WATCH LOG
When it is time to enter responses into the watch, circle your answers here first (starting with #1 WAKE UP TIME IN THE MORNING) and then put them into the watch. Please record the actual time you enter the responses. REMEMBER TO WAIT 30 SECONDS BETWEEN EACH ANSWER! If you can't enter responses within 30 minutes of the time you are supposed to, skip those and wait until the next time point.

Questions about your SLEEP last night (just record in log book, not in watch):
a. How many hours did you sleep last night? _____

b. How much time passed from the time you wanted to get to sleep until you actually got to sleep (circle one)?
1 = 0 to 30 minutes   **2** = 30 to 60 minutes   **3** = 60 to 90 minutes **4** = more than 90 min.

c. How many times did you wake-up during the night which resulted in trouble getting back to sleep (circle one)?
1 = 0 times   **2** = 1-2 times **3** = 3-4 times   **4** = 5-6 times   **5** = more than 6 times

d. Did you awake earlier than you wanted to because of sleep difficulties (circle one)?
0 = on time or later   **1** = earlier

e. Overall, how would you rate your sleep quality last night on a scale from 0 – extremely poor to 5 – extremely good? _____

f. Overall, how rested do you feel after last night's sleep on a scale from 0 – not at all rested to 5 – well rested? _____

ENTER THESE RESPONSES INTO THE WATCH:

1. WAKE UP TIME IN THE MORNING (___ - ____am): Actual Time_____

Please enter these responses into the watch even though there was no alarm.

Pain
0	1	2	3	4	5	6	7	8	9	10
No Pain										**Pain as bad as you can imagine**

Fatigue
0	1	2	3	4	5	6	7	8	9	10
No Fatigue										**Fatigue as bad as you can imagine**

How severe do you think your pain will be until the next time-point?
0	1	2	3	4	5	6	7	8	9	10
No Pain										**Pain as bad as you can imagine**

During the past few hours, have you gone slowly and taken breaks to do your activities?

0	1	2	3	4
Not at All	Very Little	Sometimes	Most of the Time	Always

During the past few hours, have you maintained a reasonable pace during activities (not too fast or too slow) to reduce the effect of pain on what you were doing?

0	1	2	3	4
Not at All	Very Little	Sometimes	Most of the Time	Always

During the past few hours, did you break activities into manageable pieces to do them?

0	1	2	3	4
Not at All	Very Little	Sometimes	Most of the Time	Always

---

2. FOUR HOURS AFTER YOU WAKE UP (__:00-__:30 am): Actual Time_____

Pain

0	1	2	3	4	5	6	7	8	9	10
No Pain										Pain as bad as you can imagine

Fatigue

0	1	2	3	4	5	6	7	8	9	10
No Fatigue										Fatigue as bad as you can imagine

How severe do you think your pain will be until the next time-point?

0	1	2	3	4	5	6	7	8	9	10
No Pain										Pain as bad as you can imagine

During the past few hours, have you gone slowly and taken breaks to do your activities?

0	1	2	3	4
Not at All	Very Little	Sometimes	Most of the Time	Always

During the past few hours, have you maintained a reasonable pace during activities (not too fast or too slow) to reduce the effect of pain on what you were doing?

0	1	2	3	4
Not at All	Very Little	Sometimes	Most of the Time	Always

During the past few hours, did you break activities into manageable pieces to do them?

0	1	2	3	4
Not at All	Very Little	Sometimes	Most of the Time	Always

---

3. AFTERNOON (__:00-__:30 pm): Actual Time_____

Pain

0	1	2	3	4	5	6	7	8	9	10
No Pain										Pain as bad as you can imagine

Fatigue

0	1	2	3	4	5	6	7	8	9	10
No Fatigue										Fatigue as bad as you can imagine

How severe do you think your pain will be until the next time-point?

0	1	2	3	4	5	6	7	8	9	10
No Pain										Pain as bad as you can imagine

During the past few hours, have you gone slowly and taken breaks to do your activities?

0	1	2	3	4
Not at All	Very Little	Sometimes	Most of the Time	Always

During the past few hours, have you maintained a reasonable pace during activities (not too fast or too slow) to reduce the effect of pain on what you were doing?

0	1	2	3	4
Not at All	Very Little	Sometimes	Most of the Time	Always

During the past few hours, did you break activities into manageable pieces to do them?

0	1	2	3	4
Not at All	Very Little	Sometimes	Most of the Time	Always

---

4. EVENING (__:00-__:30 pm): Actual Time_____

Pain

0	1	2	3	4	5	6	7	8	9	10
No Pain										Pain as bad as you can imagine

Fatigue

| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

No Fatigue

Fatigue as bad as you can imagine

How severe do you think your pain will be until the next time-point?

| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

No Pain

Pain as bad as you can imagine

During the past few hours, have you gone slowly and taken breaks to do your activities?

| 0 | 1 | 2 | 3 | 4 |
| Not at All | Very Little | Sometimes | Most of the Time | Always |

During the past few hours, have you maintained a reasonable pace during activities (not too fast or too slow) to reduce the effect of pain on what you were doing?

| 0 | 1 | 2 | 3 | 4 |
| Not at All | Very Little | Sometimes | Most of the Time | Always |

During the past few hours, did you break activities into manageable pieces to do them?

| 0 | 1 | 2 | 3 | 4 |
| Not at All | Very Little | Sometimes | Most of the Time | Always |

---

5. 30 MINUTES BEFORE BED: Actual Time_____

Pain

| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

No Pain

Pain as bad as you can imagine

Fatigue

| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

No Fatigue

Fatigue as bad as you can imagine

How severe do you think your pain will be until the next time-point?

| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

No Pain

Pain as bad as you can imagine

During the past few hours, have you gone slowly and taken breaks to do your activities?

0	1	2	3	4
Not at All	Very Little	Sometimes	Most of the Time	Always

During the past few hours, have you maintained a reasonable pace during activities (not too fast or too slow) to reduce the effect of pain on what you were doing?

0	1	2	3	4
Not at All	Very Little	Sometimes	Most of the Time	Always

During the past few hours, did you break activities into manageable pieces to do them?

0	1	2	3	4
Not at All	Very Little	Sometimes	Most of the Time	Always

Did you enter all timepoints into the watch?   YES   NO
Which one(s) did you skip?_____

Activity Log

This will be a log of your activities and medications while you are a participant in this study. You can do this at the end of the day and we're hoping it won't take you more than 10 minutes to complete. We will use this information you provide to help us better interpret your activity monitor data, medication intake, and to make sure that you are following the study instructions.

Please make sure to record what time you wake up in the morning and what time you go to bed at night. <u>**Also please record the times you remove the watch, for how long and the reason such as a shower,swimming, nice dinner ect.**</u>

Also write down different things that you did throughout the day. For example:

Time	Description of Activity
Before 7:00 am	Sleeping
7:00am - 9:00 am	Got up at 8:00 am, showered, read paper
9:00 am - 11:00 am	Went to work and worked at desk
11:00 am - 1:00 pm	Met friends for lunch
1:00 pm - 3:00 pm	At work in meetings all afternoon
3:00 pm - 5:00 pm	
5:00 pm - 7:00 pm	Left work at 5:00, Went to grocery store, bank, and post office
7:00 pm - 9:00 pm	Made dinner, watched TV
9:00 pm - 11:00 pm	Went to bed at 10:45

Wake Up Time	Bed Time
8:00 am	10:45

<u>**Did you take off the watch?**</u>   **YES**   **NO**   *If YES, please fill out chart*

What Time(s)?	8:00am			
For How Long?	15 minutes			
Reason?	Shower			

We also would like to know what medications you took each day. For example:

List Medication	Time Taken	Was it taken to relieve pain?
1. ibuprofen	1:00	Yes

Time	**Description of Activity**

Before 7:00 am	
7:00am - 9:00 am	
9:00 am - 11:00 am	
11:00 am - 1:00 pm	
1:00 pm - 3:00 pm	
3:00 pm - 5:00 pm	
5:00 pm – 7:00 pm	
7:00 pm – 9:00 pm	
9:00 pm - 11:00 pm	
11:00 pm –	

Wake Up Time	Bed Time

Did you take off the watch for a time period greater than 5 minutes?
(Circle one) YES   NO
If YES, please fill out chart

What Time(s)?				
For How Long?				
Reason?				

Daily Medication Use:

List Medication	Time Taken	Was it taken to relieve pain?
1.		
2.		
3.		
4.		
5.		