DO REDUCTIONS IN PAIN CATASTROPHIZING MEDIATE THE POSITIVE EFFECT OF MINDFULNESS-BASED INTERVENTIONS ON DISABILITY AND PAIN? A SYSTEMATIC REVIEW OF THE LITERATURE

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Table of Contents

Abstract

Background: Chronic pain is a psychosomatic condition in which a real physical problem exists, but cognitive factors play a large role in the pain experience. It is a significant public health concern that creates substantial burdens on its sufferers. Psychological models of chronic pain, such as the Fear-Avoidance Model, show that the way people interpret and respond to their pain sensations is a strong determinant of their future pain experience. In that vicious circle of chronic pain, pain catastrophizing, the exaggerated negative cognitive response to bodily sensations, is a central variable predicting functional disability and pain. Consequently, any mechanism that can reduce pain catastrophizing or make changes in its process may be beneficial in interrupting the Fear-Avoidance cycle. In recent years, mindfulness-based interventions for chronic pain received a lot of attention. They are based on the concept of mindfulness, cultivating an intentional, non-judgmental awareness of the present moment. Therefore, in theory, it is counteractive to the conceptual processing and judgement involved in catastrophizing. In fact, numerous cross-sectional studies have shown that trait mindfulness negatively correlates with pain catastrophizing. **Purpose:** First, the objective of this review is to systematically examine the existing evidence on the contribution of pain catastrophizing in predicting disability and pain in chronic pain patients. It is hypothesized that a) pain catastrophizing is positively associated with disability and pain. Second, there will be an examination of empirical studies on the effect of mindfulness-based interventions on pain catastrophizing in chronic pain patients. It is assumed that b) mindfulness-based interventions decrease pain catastrophizing scores. Ultimately, limitations of each study will be evaluated, and implications for research and practice will be suggested. **Method:** A literature search was undertaken using the electronic databases PubMed, PsycINFO, PSYNDEX and references of retrieved articles. Only English articles were included. Ten studies for each hypothesis were found. **Results:** Pain catastrophizing is associated with disability and pain outcomes among chronic pain patients with moderate to large effect sizes in nine out of ten studies. Mindfulness-based interventions significantly reduce pain catastrophizing levels in eight out of ten studies. **Discussion:** There is a lack of longitudinal studies that manipulate levels of pain catastrophizing in order to find the true causal pathway. Better designed large-scale studies, which examine the effect of standardized mindfulness-based interventions on pain catastrophizing in chronic pain patients, are needed as well. Further research is necessary to determine additional mediators, such as fear, attention, and acceptance.

Keywords: Mindfulness, Chronic Pain, Fear-Avoidance Model, Pain Catastrophizing, Catastrophic thinking, Mindfulness-Based Interventions, Disability, Pain Intensity.

Introduction

In *The Power of Now*, the author Eckhart Tolle writes, “Do not resist the pain. Allow it to be there. Surrender to the grief, despair, fear, loneliness, or whatever form the suffering takes. Witness it without labeling it mentally. Embrace it. Then see how the miracle of surrender transmutes deep suffering into deep peace.” (Tolle, 2004, p. 221). Not only do Tolle’s words describe the emotional distress that physical pain brings, but also the author offers a solution that might be counterintuitive to many people with chronic pain: to surrender and embrace the pain. In particular, he suggests one essential mental skill that has been receiving more and more attention in clinical practice in the past decade: *mindfulness*. The idea that mindfulness has a positive effect on chronic pain lays the foundation of the present bachelor thesis. What is chronic pain exactly, and why is it necessary for psychologists to deal with a seemingly purely physical issue? Chronic pain is a common disabling illness, estimated to affect about 20% of adult European population. It has a major negative impact on the sufferers’ quality of life, often leading to disability, insomnia, and dependency on other people’s help (Breivik, Collett, Ventafridda, Cohen, & Gallacher, 2006). Chronic pain is associated with very large costs for the society, including costs for sick leave and healthcare (Häuser et al., 2014; Maniadakis & Gray, 2000). Patients have been reported to use healthcare services up to five times more, compared with the rest of the population (Von Korff, Wagner, Dworkin, & Saunders, 1991). It becomes clear that chronic pain is a huge burden to society, whereas its relevance is often underrated. Furthermore, it is only recently that clinical psychologists are involved in its treatment: In 2009, the German version of *ICD-10* (Dilling, Mombour, Schmidt, Schulte-Markwort, & Remschmidt, 2015) introduced the diagnosis of "chronic pain disorder with somatic and psychological factors" to address the biopsychosocial factors involved in chronic pain, even in those conditions with a clear biological cause in the beginning (Nilges & Rief, 2010). There are models that emphasize the psychological aspects of chronic pain. For instance, the *Fear-Avoidance Model* has provided a cycle of how chronic pain develops and persists, based on the idea that fear of pain is a central element (Vlaeyen & Linton, 2000; Lethem, Slade, Troup, & Bentley, 1983). Findings in 1995 (Vlaeyen, Kole-Snijders, Boeren, & Van Eek) suggested that pain-related fear evolves from *pain catastrophizing*, which occurs when pain is perceived as threatening. In short, pain catastrophizing can be described as a negative cognitive and affective appraisal of body sensations, characterized by rumination, helplessness, and magnification towards the pain (Sullivan, Bishop, & Pivik, 1995). In the Fear-Avoidance Model it plays an essential role in predicting the pain experience (Vlaeyen & Linton, 2000). As can be seen, pain catastrophizing is certainly not at all insignificant. But how is mindfulness associated

with that? There have been numerous studies demonstrating the positive effects of psychological treatments on chronic pain (Dixon, Keefe, Scipio, Perri, & Abernethy, 2007), including *mindfulness-based interventions* (MBIs; Jensen, 2011). Mindfulness is defined as an intentional process of bringing attention and nonjudgmental awareness to the present moment (Kabat-Zinn, 1982). It seeks to teach that thoughts are transient mental events rather than reality, which helps to reduce ruminative thinking in clients (Bishop et al., 2004). A correlational research study examined the association between mindfulness and pain catastrophizing (Schütze, Rees, Preece, & Schütze, 2010). It was found that trait mindfulness strongly negatively correlates with variables of pain catastrophizing, concluding that mindfulness might reduce catastrophic thinking in a unique way. However, the most common treatment for chronic pain patients involves analgesic and opioid drugs. Drugs can improve symptoms, but even the most potent ones reduce pain by only 30 % (Turk, Loeser, & Monarch, as cited in Turk, 2002). Yet, biomedical approaches often focus on only structural abnormalities, while cognitive factors are being ignored (Crombez, Eccleston, Van Damme, Vlaeyen, & Karoly, 2012).

Given the large negative individual and economic consequences, it is of great interest to establish effective methods in order to reduce the pain experience in chronic pain patients (Goldberg, & McGee, 2011). Thus, the aim of this systematic review is to summarize the current state of research on the importance of pain catastrophizing in the chronic pain experience, and the influence of MBIs on pain catastrophizing in chronic pain patients. The primary goal of this investigation is to improve therapies for chronic pain patients, and to expand the research on mechanisms involved in mindfulness and pain. The secondary goal is to raise awareness on the mind-body connection and the large influence of thoughts and beliefs on physical functioning. Unfortunately, this complex interrelationship between mind and body is still greatly underestimated.

Theoretical Background

The following section describes the main concepts, theories, and background data. In the beginning, chronic pain and its consequences will be outlined more precisely to underscore the necessity to find an appropriate intervention. Definition, prevalence, and costs will be summarized briefly. In the next step, two major models that explain the development of chronic pain, namely the *Biopsychosocial Model* and the Fear-Avoidance Model, will be illustrated. The latter lays the basis for this review, in particular for hypothesis a), which says that pain catastrophizing increases disability and pain in chronic pain patients. Thereafter, pain catastrophizing will be specified, as it is the focal point of this review, and also serves as a key factor in the Fear-Avoidance Model. After that, the existing medical, non-medical, and psychological treatments will be depicted shortly. Eventually, the concept of mindfulness will be described, as well as how it is practiced, and which clinical interventions implement it. After the basic ideas and terms have become clear, the deduction of the hypotheses of this review will be explained.

Chronic Pain

Chronic pain is defined as a pain lasting longer than 3 months and past the healing time (Merskey, 1986). Therefore, it lacks the acute warning function of physiological nociception (Treede, 2013). In fact, there is a distinction that can be made between nociception and pain: Nociception is a sensory nervous response to a pain stimuli about a potential harmful tissue damage, while pain is the subjective perception of it. It is subjective because cognitive and affective factors, as well as personality profiles, highly influence individual perception. For instance, negative personality profiles involving anxiety can alter pain sensitivity. Moreover, priori knowledge and expectations about a stimulus enormously contribute to the pain experience (Coghill, 2010). Referring to this matter, the Biopsychosocial Model of chronic pain says that mechanisms underlying chronic pain include an interaction of biological, psychological, and social factors. Therefore, each individual responds to stimuli differently (Gatchel, Peng, Peters, Fuchs & Turk, 2007; Turk & Flor, 1999). But how many people are actually affected by this condition? Chronic pain is common in Europe, occurring in approximately 20% of adult Europeans and seriously affecting many aspects of life in a negative way, as a telephone-survey with about 46 thousand participants found out (Breivik et al., 2006). As a matter of fact, a study of 2008 (Tsang et al.) discovered a chronic pain prevalence of 41% in developing countries. Surprisingly, a Dutch study with a sample of 5300 children from 4 to 18 years stated that chronic pain is not only common among adults, but also among children

and adolescents to a similar extend (Perquin et al., 2000). Chronic pain prevalence rises with increasing age and affects about 60% of the people above 75 years. In consequence, with an aging population, the burden of chronic pain is prospectively likely to rise (Fayaz et al., 2016). To continue with the repercussions, chronic pain has direct costs, as healthcare costs, and indirect costs, such as loss of productivity at work. In Europe, these costs were estimated to account for 3% to 10 % of the countries' gross domestic product (Breivik, Eisenberg, & O'Brien, 2013). Roughly 60 % of the affected people say they are less able or unable to work outside of home (Breivik et al., 2006). This results in a great economic impact, greater than most other health conditions, due to incapacity for work and early retirement (Maniadakis & Gray, 2000; Saastamoinen et al., 2012). Altogether, public sector costs per patient per year, including health and social care, range from €2089 for low back pain in Germany to €9982 for fibromyalgia in Spain (Müller-Schwefe et al., 2011; Marañón et al., 2009). It is apparent that there is both a high prevalence, and high costs of chronic pain.

As mentioned earlier, the Biopsychosocial Model and the Fear-Avoidance Model attempt to explain the development and persistence of chronic pain with regard to cognitive and emotional factors. In the upcoming paragraphs, these major models will be clarified.

The Biopsychosocial Model

Since the focus of this thesis lies on the psychological aspects involved in the chronic pain experience, the Biopsychosocial Model of chronic pain cannot be disregarded. The model helps to understand how the patient's subjective psychological and social factors affect the pain experience. In fact, this model is applicable to a broad spectrum of illnesses, both physical and mental.

The Biopsychosocial Model has been developed in 1980 (George & Engel) and describes disease as an interaction between biological, psychological, and sociocultural factors. Biological factors include nerve damages, injuries, and infections. Social aspects involve friends, family, and work, but also social settings, such as the given sick role, or conflicts with coworkers. Psychological factors are, for instance, coping skills, anxiousness, self-esteem, and other beliefs and attitudes. For the first time a model moved away from the traditional definition of chronic pain by viewing it as not purely physical. It contributed to future research and demonstrated the significance of emotional, behavioral, and cognitive factors. In 1996 (Turk & Monarch), the Biopsychosocial Model has been specifically applied to the development of chronic pain and demonstrated how it affects all aspects of functioning, such as interpersonal relationships and mood. The updated version of the Biopsychosocial Model (Turk & Okifuji, 2002) precisely outlines how beliefs influence appraisals, which influence the person's

behavior and response. Patient beliefs include the fear of movement, which can result in maladaptive strategies, such as resting and protecting body parts. Behavior, for instance, includes continuing to work, or, on the other hand, leaving work. Resting, however, can maintain disability, and even increase pain perception. We can see how psychological, social, and biological factors, such as work and disability, reciprocally interact. Aside from that, the model shows how these three dimensions can contribute to the development of chronic pain, and also how chronic pain subsequently affects these three dimensions. The reason this model is so important is that it underlines the need for biopsychosocial approaches to the treatment of chronic pain as well. Moreover, since the model had been published, a growing number of literature has been focusing on factors that are not organic to describe the development of chronic pain. Expectations, beliefs, and emotional factors gained substantial significance (Turk & Okifuji, 2002). This is a simplified illustration of the model based on Gatchel et al. (2007):

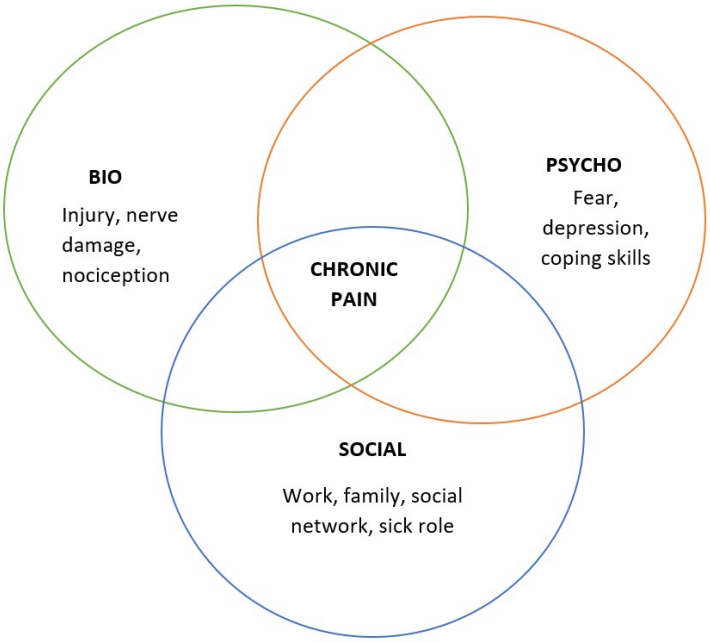

Figure 1. The biopsychosocial model

The Fear-Avoidance Model

The Fear-Avoidance Model of chronic pain (FAM) is a circular model that attempts to explain how chronic pain evolves and maintains (Vlaeyen & Linton, 2000). This model is the center of interest in this paper, because literature that addresses chronic pain frequently mentions the FAM, and it appears to be well-known among researchers.

The FAM is based on the idea that fear of pain is a central element in the development and persistence of chronic pain (Lethem et al., 1983). In 1983, Lethem and colleagues introduced

the model and suggested that the response to the actual pain sensation predicts future pain experience. In their paper, it is said that fear of pain leads to avoidance strategies, promoting disability and exaggerated pain perception, whereas confrontation leads to higher activity, and lower pain severity. This article from 1983 built the foundation for its successor model: In 2000, the idea has been adopted by Vlaeyen and Linton, who transferred it into a cognitive and behavioral vicious cycle towards chronic pain and persistent disability. Pain catastrophizing is the first reaction to pain perception, as the model claims. Similar to other findings in 1995 (Vlaeyen et al.), they suggested that pain-related fear evolves from pain catastrophizing, which occurs when pain is perceived as threatening. In the next step, fear causes hypervigilance and avoidance behavior, which then leads to disability, disuse, and depression. *Disuse syndrome* is the result of prolonged physical disability and adverse conditioning (Bortz, 1984). This maintains and heightens the pain experience, causing the cycle to repeat itself. At the same time the model offers a solution: it claims that if injury or pain is perceived in a nonthreatening manner, patients do not feel fear and will confront and adapt, which leads to fast recovery.

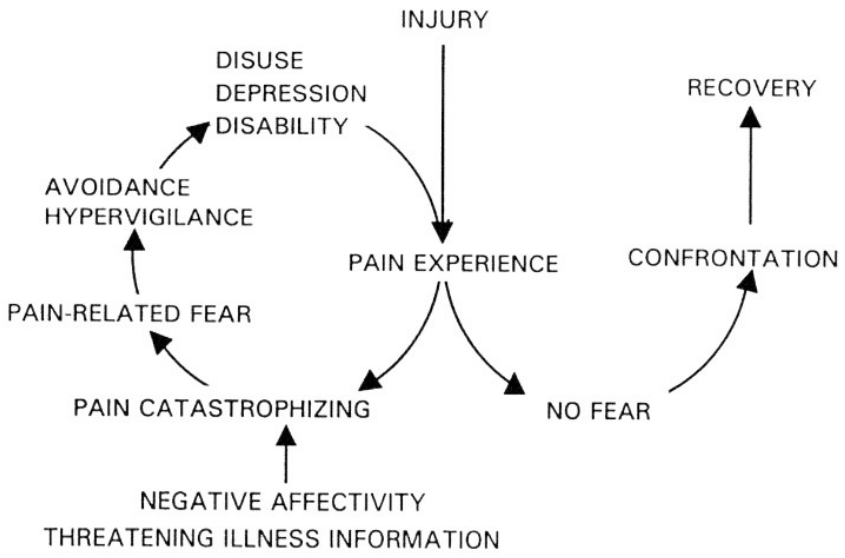

Figure 2. The fear-avoidance model (Vlaeyen & Linton, 2000)

In the context of fear, the term *Fear-Avoidance belief* occurs frequently. Fear-Avoidance beliefs are beliefs about pain that cause fear of movement or reinjury (Vlaeyen & Linton, 2000). It is often referred to *kinesiophobia*, which is described as an excessive and irrational fear of physical movement and activity due to a feeling of vulnerability (Picavet, Vlaeyen, & Schouten, 2002; Swinkels-Meewisse, Swinkels, Verbeek, Vlaeyen, & Oostendorp, 2003). Furthermore, it has been said that the fear of pain, injury, or reinjury can be more disabling than the pain itself (Crombez, Vlaeyen, Heuts, & Lysen, 1999). This is interesting for this review, because one of

the first studies on that topic suggested that fear evolves from catastrophizing (Vlaeyen et al., 1995), and that there is substantial overlap between catastrophizing and fear. This will be explored further in the discussion. In other words, the FAM says that a significant proportion of chronic pain sufferers interpret pain in a catastrophic way, which causes pain-related fear and behavioral avoidance. Avoidance leads to negative psychological and physical consequences, such as depression, disuse, and disability. This causes more intense pain. Additionally, the model describes how acute pain can turn into chronic pain.

In brief, the model claims that pain-related fear and pain catastrophizing are the major psychological components linked to exaggerated pain perception, and development and persistence of chronic pain (Vlaeyen & Linton, 2000). This thesis focuses on pain catastrophizing, as it is displayed as the first reaction to pain perception in the model. In addition to that, it seems like catastrophizing is the exact antithesis to mindfulness, which promotes a nonreactive and nonjudging mental state.

Pain Catastrophizing

As mentioned previously, the FAM considers pain catastrophizing as a crucial variable in the development and persistence of chronic pain. The term *catastrophizing* was first introduced by Albert Ellis (1962) and was then adapted by Aaron Beck (1979) to describe negative cognitions in patients with anxiety and depression. Pain catastrophizing is defined as an exaggerated perception of threat value or seriousness of a pain sensation (Chaves & Brown, 1987). It had mainly been used in the context of depression before its relation to pain was examined. In Beck's cognitive model, catastrophizing is a cognitive error that increases depressive symptoms (Beck, 1979). Similar to that, studies demonstrated that pain catastrophizing is linked to depression, neuroticism, and worry (Sullivan & D'Eon, 1990; Affleck, Tennen, Urrows, & Higgins, 1992). Chronic pain patients have much higher pain catastrophizing levels than the general population (Domenech, Sanchis-Alfonso, & Espejo, 2014). Not surprisingly, depression is more common in chronic pain patients as well (Fishbain, Cutler, Rosomoff, & Rosomoff, 1997). In fact, studies indicated that chronic pain patients have a higher risk of suicide ideation, suicide attempts, and suicide completion (Fishbain, 1999). Along with this, one study claimed that not pain severity or duration were predictors of suicide ideation, but the magnitude of depressive symptoms and pain catastrophizing. This underscores the importance of addressing pain catastrophizing in the management of chronic pain.

There are theoretical conceptualizations that attempt to explain the mechanisms underlying pain catastrophizing and its pain-related outcomes. They will be described in the following.

Theories of pain catastrophizing. The *Appraisal Model* views catastrophizing as an appraisal process (Lazarus & Folkman, 1984). The theory says that emotions evoke from evaluation, or rather appraisal, of events. *Primary appraisal* is the way the stimulus is interpreted, whether it is irrelevant, relevant, positive, or negative. *Secondary appraisals* are beliefs and thoughts about coping strategies, and whether they will be efficient or not. Referring to pain catastrophizing, magnification and rumination are primary appraisals of pain stimuli, while helplessness is a secondary appraisal.

The *Communal Coping Model* underlies an interpersonal theory that characterizes catastrophizing as a coping strategy that leads to empathy and emotional support of others (Sullivan et al., 2001). As a matter of fact, a study found that pain catastrophizing in chronic pain patients was greater when the spouse was around to witness the patient's distress (Thorn, Ward, Sullivan, & Boothby, 2003).

Finally, the *Attention Model* describes the mechanism in pain catastrophizing as an attentional bias. A study showed how catastrophizers are hypervigilant for threatening information and find it hard to divert attention away from the stimuli (Crombez, Eccleston, Baeyens, & Eelen, 1998). Eccleston and Crombez (1999) proposed that people selectively pay attention to pain-related stimuli while experiencing pain. Pain has an interruptive function and interferes with ongoing mental processes. The Attention Model says that this attention and information processing bias intensifies the pain experience by exaggerated attention towards the threatening stimuli. These models should be kept in mind as they justify the hypotheses later in this review.

Assessment of pain catastrophizing. Since all of the included studies in this thesis either use the *Pain Catastrophizing Scale* (PCS), or the *catastrophizing* subscale of the *Coping Strategies Questionnaire* (CSQ), as the main assessment tools, it is essential to know which dimensions they comprise, and which items they implement. It also helps to develop an in-depth understanding of the construct of pain catastrophizing, which is necessary for both research questions. The PCS and the CSQ are the most common self-report instruments for measuring pain catastrophizing, while the PCS is considered a broader assessment of the catastrophizing construct (Quartana, Campbell, & Edwards, 2009). The PCS is a useful instrument to examine catastrophizing in chronic pain patients, and to identify heightened distress responses to aversive stimuli. The scale consists of 13 items and measures three dimensions of catastrophic thinking: *magnification*, *rumination*, and *helplessness*. There are scores from 0 (*not at all*) to 4 (*all the time*) to rate the degree to which one has certain thoughts while feeling pain. A high score stands for a high use of catastrophic thinking. The PCS has found to have a high retest reliability and internal consistency. Therefore, it is a reliable and

valid measure of pain catastrophizing (Sullivan et al., 1995). The PCS subscales comprise following statements:

Helplessness Subscale

I worry all the time about whether the pain will end.
I feel I can't go on.
It's terrible and I think it's never going to get any better.
It's awful and I feel that it overwhelms me.
I feel I can't stand it anymore.
There is nothing I can do to reduce the intensity of the pain.

Rumination Subscale

I anxiously want the pain to go away.
I can't seem to keep it out of my mind.
I keep thinking about how much it hurts.
I keep thinking about how badly I want the pain to stop.

Magnification Subscale

I become afraid that the pain may get worse.
I think of other painful experiences.
I wonder whether something serious may happen.

Rumination accounts for the largest proportion of variance in the Pain Catastrophizing Scale (Sullivan et al., 1995). This is interesting, because MBIs are known to target and reduce rumination among individuals with depression (Wilson, Ong, & Koopman, 2009).
In addition, pain catastrophizing can be assessed with the catastrophizing subscale of the CQS, which was developed in 1983 (Rosenstiel & Keefe). It is a six-item subscale with the following statements:

It’s terrible and I feel like it’s never going to get any better.
It is awful and I feel it overwhelms me.
I worry all the time about whether it will end.
I feel my life isn’t worth living.
I feel like I can’t go on.
I feel I can’t stand it anymore.

Treatments for Chronic Pain

A comprehensive overview of models and theories that explain chronic pain and underlying psychological mechanisms, especially pain catastrophizing, was given in the preceding paragraphs. Now, the question is what treatment options are available for chronic pain patients in practice. Knowing the existing therapies enables to put mindfulness-based interventions into a wider clinical context.

In general, opioids are the most common treatment for chronic pain. There has been a dramatic increase in opioid prescriptions, often accompanied by overdose and addiction (Boudreau et al., 2009; Volkow & McLellan, 2016). Evidence supports the increased risk for serious harms associated with long-term opioid therapy (Chou et al., 2015). In fact, a study found that medications reduce pain by about 30% in chronic pain patients, hence, do not fully eliminate pain (Turk, Loeser, & Monarch, as cited in Turk, 2002). There are various treatments for chronic pain apart from pharmaceutical approaches, such as exercise, massage and physical rehabilitation, alternative treatments including acupuncture, interventional techniques including nerve blocks, surgery, and psychological treatments, all showing positive effects (Turk, Wilson & Cahana, 2011; Chou & Huffman, 2007). Addressing this issue from a psychological perspective is of great significance, because opioid therapy seems to be not at all sufficient. Apart from that, the Biopsychosocial Model and the Fear-Avoidance Model clearly show that chronic pain is certainly not only a biological matter. This is why it is necessary that not only physicians, but also psychologists deal with this issue.

Psychological treatments for chronic pain. Individuals suffering from chronic pain often develop maladaptive cognitions and behavior, which worsen the experience of pain (Thibault, Loisel, Durand, Catchlove, & Sullivan, 2008). There has been a large number of empirical studies demonstrating the efficacy of psychological treatment beyond the effects of standard medical care (Dixon et al., 2007). Moreover, in comparison with medication, the advantages of psychological treatments include improvements in comorbid conditions such as depression and anxiety, no risk of abuse, and low risk of contraindication and side effects (Valentine & Deimling, 2018). The most common psychological treatments are *cognitive-behavioral therapy* (CBT), *hypnosis*, *Acceptance and Commitment Therapy* (ACT), and mindfulness-based interventions (Sturgeon, 2014; Adachi, Fujino, Nakae, Mashimo, & Sasaki, 2014). The following will briefly describe these treatments.

CBT is an empirically supported pain treatment (Chambless, 1998). It had become the common standard of psychosocial intervention for pain. Maladaptive beliefs and dysfunctional behavior, such as avoidance, are specifically targeted in CBT (Morley, Eccleston, & Williams, 1999).

Hypnosis is a way of using the patient's subconscious resources by hypnotic inductions to distract and reduce pain in a clinical setting (Patterson, 2010). ACT fosters acceptance of unpleasant events, such as the pain itself, and awareness of thoughts and emotions that occur. Moreover, the individuals are asked to identify personal values and goals, so that they adjust their behavior to these. ACT and MBIs share the concept of mindfulness and acceptance of pain, but unlike MBIs, ACT does not involve mindfulness meditation (McCracken & Vowles, 2014). MBIs, which are the focus of this review, promote mindfulness by practicing meditation and the ability to stay in the present moment, with no judgement or interpretation of perceptions (Bishop et al., 2004). There has been a shift from behavioral and cognitive therapies to mindfulness and acceptance approaches over the past 15 years. Therefore, mindfulness interventions and ACT are often known as "third wave" treatments (Hayes, 2004).

As mentioned before, this review focuses on MBIs. Part of the reason for that is that MBIs have not yet fully been investigated, since it has not been long ago that they have been established and implemented in clinical practice. This allows us to expand the research and gain fundamental new insights on the effects of MBIs, specifically for chronic pain. Another very important reason why particularly MBIs were chosen for this review is that they can be perfectly applied to the Fear-Avoidance Model, which is a major model in chronic pain literature. The reason for this is that mindfulness theoretically counteracts pain catastrophizing, a crucial factor contributing to chronic pain in the FAM, as Schütze et al. (2010) claimed. A thorough description of mindfulness and MBIs is provided in the following paragraphs.

Mindfulness

In what follows, the concept of mindfulness and its practical application in a clinical setting will be outlined. In order to comprehend the ground of hypothesis b), which is that MBIs improve pain catastrophizing, the concept of mindfulness needs to be fully understood.

Mindfulness is a way of paying attention to moment-by-moment experience, on purpose and nonjudgmentally (Kabat-Zinn, 1990). It originated in eastern Buddhist meditation practices and traditions, which have their roots in India (Bishop et al., 2004). Mindfulness is a key concept of Buddhism. It has a history of over 2,500 years, and over the years mindfulness spread over Asia and reached the West (Kuan, 2007). However, western clinicians teach mindfulness skills independently of religion (Kabat-Zinn, 1982). A study examined the mindfulness construct on its components and discovered five facets of mindfulness: *observing*; *describing*; *acting with awareness; nonjudging of inner experience*; and *nonreactivity to inner experience* (Baer, Smith, Hopkins, Krietemeyer & Toney, 2006). Moreover, one can differentiate between state and trait mindfulness: state mindfulness is the increased awareness that arises during meditation

practice, while trait mindfulness describes lasting changes on mindfulness dimensions (Cahn & Polich, 2006). Trait mindfulness can be a natural quality, a disposition, while state mindfulness is rather fluctuating and temporary (Brown & Ryan, 2003). Since meditation is the key practice in MBIs, the upcoming paragraph is essential (Kabat-Zinn, 1982). Also, in this paper it is assumed that the mechanisms involved in meditation are crucial for the reduction of pain catastrophizing.

Mindful meditation. Meditation primarily affects the psychological domain of attention, as a study found (Davidson & Goleman, 1977). Various types of meditation are being practiced in mindfulness treatments. The main principle of all the practices is as follows: The patients sit upright and try to pay attention to a specific attribute, such as their own body sensations or breathing. Whenever thoughts and feelings occur, the patients are supposed to notice them, let them go, and return attention to their focus. Meditation encourages to accept each thought and emotion that arises, without judging, elaborating, or taking action as a response (Kabat-Zinn, 1990; Bishop et al., 2004). Bishop et al. (2004) defined mindfulness through two components:

1. *Self-regulation of attention*
2. *Orientation to experience*

Self-regulation of attention involves increased awareness, recognition, and observation of the present mental events. It fosters direct experience of sensations, thoughts, and feelings, rather than ruminations and interpretations of them. To inhibit further elaboration, patients draw their attention back to their breath or body after observing the thoughts. Beliefs, expectations, and assumptions are not part of the observing experience. Instead, a welcoming attitude is the way of approaching these. Orientation to experience involves acceptance, openness, and curiosity towards the experience. Acceptance is defined as being open to the reality of the present moment (Roemer & Orsillo, 2002). Bishop et al. (2004) assumed that curiosity and acceptance reduce the use of cognitive avoidance strategies. Furthermore, they lead to a more pleasant subjective meaning of distress due to a change of context. However, the meditator or patient is not supposed to seek relaxation or any other particular results. The standard interventions that train mindfulness are described in detail in the upcoming paragraphs. In this review, it is assumed that mindfulness-based interventions cause a decrease in pain catastrophizing in chronic pain patients.

Mindfulness-Based Interventions

Mindfulness-based interventions encourage emotional distance from thoughts through nonjudgmental observations of arising stimuli (Baer, 2003). They intend to improve the ability to disengage from maladaptive patterns so that individuals learn to cope with stress in a healthier way (Bishop et al., 2004). For the past three decades, MBIs have increasingly been used for the treatment of chronic pain, as well as depression and anxiety. High quality studies have shown significant improvements in psychological stress, depressive recurrence, anxiety, and pain (Creswell, 2017; Grossman, Niemann, Schmidt, & Walach, 2004; Fjorback, Arendt, Ørnbøl, Fink, & Walach, 2011). *Mindfulness-based stress reduction* (MBSR) was the first therapeutic practice involving mindfulness. It was developed in 1979 by Jon Kabat-Zinn with the primary intention to create an intensive mindfulness meditation training for medical patients who suffer from stress, pain, and illness. Kabat-Zinn and colleagues were the first to introduce meditative practices to treat chronic pain (Kabat-Zinn, 1990). Nowadays, MBSR programs are offered in clinics, workplaces, schools, and health centers all around the world, showing positive effects on participants (Carsley, Khoury, & Heath, 2018; Jamieson & Tuckey, 2017; Xu, Jia, Liu, & Hofmann, 2016). MBSR has proven to have a medium significant effect on both physical and mental health in clinical and non-clinical populations (Grossman et al., 2004). The standard program is an 8-week course with up to 30 participants. They meet once a week for about 2.5 hours and practice mindfulness meditation under instruction. Around the sixth week, an intensive all-day mindfulness session is held. The participants are instructed to practice a certain meditation with the help of audiotapes for at least 45 min a day for the remaining six days. In addition to various meditation practices, the participants discuss homework assignments and their effects, but also personal experience with stress and coping. Meditation practices include body-scan, yoga, sitting meditation, and walking meditation. Mindfulness is also practiced during ordinary daily activities, such as eating and drinking (Baer, 2003). Another significant and well-known mindfulness intervention is *mindfulness-based cognitive therapy* (MBCT). In 2002, Segal and colleagues developed MBCT to extend the use of meditation into psychiatry (Segal, Williams, & Teasdale, 2002). This clinical intervention combines aspects of CBT and MBSR, and was specifically designed to reduce patterns of depressive thinking in patients with recurrent major depression. Studies assume that MBCT approximately halves the risk of a future relapse of depression. It is unlikely to be effective in acute depression due to concentration and attention difficulties. Similar to MBSR, MBCT is delivered by an instructor in 8 weekly sessions of 2 to 2.5 hours, involving up to 12 recurrently depressed patients. Homework assignments include awareness exercises for daily activities, as

well as guided and unguided meditation practices. One central aim of MBCT is to teach the patients to go from “autopilot”, which is a mode of automatic and habitual patterns, to a full awareness of the present experience and activity (Teasdale et al., 2000). Today, MBSR and MBCT are the two main healthcare interventions that operationalize mindfulness (Gu, Strauss, Bond, & Cavanagh, 2015). They are also the most researched MBIs for chronic pain (Chiesa & Serretti, 2011). In general, MBIs are used for the treatment of chronic pain conditions such as low back pain, migraine, and musculoskeletal pain (Majeed, Ali, & Sudak, 2018). They encourage the patients to change their relation to pain by letting go thoughts and interpretations about the pain. Mindfulness meditation needs constant concentration to maintain attention. However, unlike concentration meditation, which restricts attention to a single object, mindfulness meditation emphasizes on detached observation. Objects of observation, which can be thoughts, emotions, and pain stimuli, are intentionally regarded with an effort to be simply aware of them, if they occur. By not interpreting and judging, chronic pain patients can develop the ability to perceive the intense body feelings as bare sensations. Interpretations of pain sensations, such as “It’s killing me”, or the thought that the pain will last forever, can lose power only by observing them as separate (Kabat-Zinn, 1982). MBIs have shown moderate effects in the treatment of chronic pain. In addition, studies demonstrated better treatment outcomes in MBIs than medication, as well as improvements in daily life activities and body image (Majeed et al., 2018). With knowledge about the concept of mindfulness-based interventions, as well as pain catastrophizing and the Fear-Avoidance Model, the rationale behind the research question becomes more transparent. The deduction of the hypotheses will be discussed further in the next section.

Research Question

The two major studies that contributed to the deduction of the hypotheses will be presented in the following. Thereafter, findings that further support the hypotheses will be summarized and evaluated. Several theories that can explain the expected results will be suggested.

Schütze and colleagues (2010) examined the relationship between mindfulness and each of the variables of the FAM in chronic pain patients, including pain catastrophizing. They found that trait mindfulness predicts pain catastrophizing in a unique way, even when the other variables are controlled. Mindfulness moderates the relation between pain catastrophizing and outcome. In brief, high trait mindfulness is linked to low pain catastrophizing, while lower mindfulness is linked to higher catastrophizing. Consequently, the ability to pay attention to the present moment with a nonjudgmental attitude decides whether a person engages in negative ruminations or not, as the paper said. It was suggested that trait mindfulness might be added to

the FAM, interrupting the path from pain experience to pain catastrophizing. The figure below shows a version of the FAM that includes mindfulness.

Figure 3. A revised version of the fear-avoidance model of chronic pain showing the proposed role of mindfulness, which moderates between pain experience and pain catastrophizing (Schütze et al., 2010)

Another study obtained similar results: greater levels of mindfulness predict lower levels of pain catastrophizing and disability. It was suggested that catastrophizing mediates the relation between "mindfulness" and "disability" (Cassidy, Atherton, Robertson, Walsh & Gillett, 2012). Assuming that high trait mindfulness leads to lower pain catastrophizing (Schütze et al.,2010; Cassidy et al., 2012), and mindfulness interventions increase trait mindfulness (Shapiro, Brown, Thoresen & Plante, 2011), following research questions have been evaluated with reference to the Fear-Avoidance Model of chronic pain: The objective of this review is first, to examine the existing evidence for the contribution of pain catastrophizing in predicting disability and pain intensity in chronic pain patients, and second, to examine the empirical evidence for the effect of MBIs on pain catastrophizing in chronic pain patients. It is hypothesized that a) pain catastrophizing is positively associated with disability and pain intensity in chronic pain patients, and b) MBIs reduce pain catastrophizing in chronic pain patients. If both hypotheses prove to be true, following general statement could be made: MBIs improve disability and pain in chronic pain patients by decreasing pain catastrophizing. A reduction in pain catastrophizing is the mediating factor for the positive effect of MBIs on disability and pain. Improvements in pain and disability in chronic pain patients after MBIs have already been stated by several studies in recent years (Morone, Greco, & Weiner, 2008; Cramer, Haller, Lauche, & Dobos, 2012; Chiesa & Serretti, 2011).

There are numerous studies that can explain why these results are expected in this thesis. Hypothesis a) is supported by studies that already investigated associations between pain catastrophizing and pain experience. For instance, a study discovered that pain catastrophizing significantly activates brain structures that are associated with pain processing, and with attentional and emotional aspects of pain. Furthermore, it activates the premotor cortex, which is related to pain behavior (Gracely et al., 2004). Additionally, Seminowicz and Davis (2006) demonstrated that high levels of pain catastrophizing lead to activity in cortical regions that are associated with attention. Both results support the Attention Model of pain catastrophizing. As explained in the theoretical background of this review, the Attention Model describes how pain catastrophizers are hypervigilant to threatening pain stimuli, which causes an attention bias. Consequently, people that catastrophize struggle with diverting attention away from the stimuli (Crombez et al., 1998). In that respect, a study proved that vigilance to pain, which is associated with heightened pain severity (Crombez, Van Damme, & Eccleston, 2005), depends on catastrophic thinking in chronic pain patients (Goubert, Crombez, & Van Damme, 2004). This leads to the rationale of hypothesis b): Assuming that pain catastrophizing causes an attention bias, MBIs could be the right approach, because they reduce pain attention bias among adults suffering from chronic pain, as a study discovered (Garland & Howard, 2013). Accordingly, a decreased attention bias might lead to reductions in pain catastrophizing after MBIs. Another study found that mindful awareness approaches decrease reactivity to aversive experiences. The undergoing mechanisms reducing reactivity might involve a fundamental attention shift from negative appraisals towards sensory aspects of the pain experience (Garland et al., 2012). Similarly, a study assumed that mindfulness helps to pay attention to body sensations rather than to negative cognitive interpretations of those, and consequently, reduce the perception of threat (Cassidy, Atherton, Robertson, Walsh, & Gillett, 2012). Therefore, one important assumption is that MBIs teach patients to detach from cognitions by bringing body sensations into focus. In other words, MBIs may help to reduce thoughts about the unpleasantness of the pain, hence, lead to less catastrophizing. One might also expect that MBIs increase pain catastrophizing due to heightened attention and awareness of the pain. But, as described in the theoretical background, Bishop et al. (2004) characterized mindfulness as both “self-regulation of attention” and “orientation to experience”. Thus, mindfulness meditation not only involves a regulation of attention, but also an open and accepting orientation to the experience. In fact, a study stated that mindful attention differs from usual attention, because it also enhances prefrontal cortical regulation of affect and, consequently, promotes detachment from negative states as well (Creswell, Way, Eisenberger, & Lieberman, 2007). Accordingly, MBIs may

change a negative appraisal to a rather neutral, or even welcoming appraisal. In this regard, a study compared long-term meditators to controls and detected that experience in meditation is associated with less anticipatory neural processing and negative appraisal of pain (Brown & Jones, 2010). Also, it was found that individuals who report higher trait mindfulness experience less negative thoughts than those who report lower mindfulness (Frewen, Evans, Maraj, Dozois, & Partridge, 2008). Therefore, the changed attitude towards the pain stimuli may reduce pain catastrophizing. This can be connected to the Appraisal Model, which was mentioned earlier, and describes pain catastrophizing as a rather negative interpretation of sensations. Finally, there is one more study that can explain hypothesis b): In 1999, Teasdale supposed that mindfulness is linked to metacognition, which is associated with an observation of thoughts. If thoughts aren't perceived as a reflection of reality, they might seem less threatening. By practicing mindfulness, patients may realize that thoughts and feelings fluctuate over time, which can reduce the need to avoid or overidentify with the discomfort. In other words, pain catastrophizing may decrease by only being aware of one's thoughts.

All in all, in this review it is assumed that reorienting attention to sensory qualities, and a more welcoming attitude towards these stimuli, are important mechanisms of MBIs. These mechanisms may lead to a reduction of pain catastrophizing in chronic pain patients who participate in a mindfulness-based intervention. In order to make the general statement that MBIs reduce pain and disability by decreasing pain catastrophizing, the relevance of pain catastrophizing has to be proven in the initial step.

Method

In March 2019, a literature search was undertaken using the electronic databases PubMed, PsycINFO, PSYNDEX, PsycNET, and references of retrieved articles. Due to a lack of articles in other languages, the search strategy considered only original articles published in English. Dissertations, unpublished articles, and pilot studies were excluded.

Literature Search Hypothesis a)

For hypothesis a) following keywords were used in various combinations: “pain catastrophizing”/ “catastrophizing”/ “catastrophic thinking”/; “pain intensity”/ ”pain”/ ”pain experience”; “disability”; “chronic pain”/ ”persistent pain”/ “chronic illness” / “chronic”.

Inclusion criteria. Studies were only included if they examined the relationship between pain catastrophizing and both pain/pain intensity and physical disability level in adult chronic pain patients. Additional inclusion criteria were: 1) assessment of sample sizes of 40 or more subjects due to representativeness, 2) assessment of the construct of pain catastrophizing through either the Pain Catastrophizing Scale or the catastrophizing subscale of the Coping Strategies Questionnaire due to reliability and validity of these tools, 3) articles published between 2000 and 2019 due to the publication of the Fear-Avoidance Model in 2000, 4) patients with non-specific clinically relevant persistent pain.

Exclusion criteria. Since hypothesis a) is based on the Fear-Avoidance Model of chronic pain, and the aim is to find an appropriate intervention target for chronic pain patients, studies with nonclinical populations or acute pain measures, as well as postsurgical pain measures, were excluded. Some studies utilized the word “interference” instead of “disability” to describe the construct of functional disability. Those studies were excluded due to inaccuracy. There were no exclusions of study populations based on gender or pain severity. Studies with samples of children and adolescents were excluded. This is not only because this thesis focuses on adults, but also because MBIs, which are part of the second hypothesis, are usually practiced on adults in a clinical setting.

Literature Search Hypothesis b)

For hypothesis b) following keywords were used in various combinations: “mindfulness”/ ”meditation”/ ”MBCT”/ ”MBSR”/ ”mindfulness-based”/ “mindfulness-based intervention”; “pain catastrophizing”/ “catastrophizing”/ “catastrophic thinking”/; “chronic pain”/ ”persistent pain”/ ”pain”/ ”chronic illness”/ “chronic”.

Inclusion criteria. Studies were only included if they implemented an MBI course, and examined its effect on pain catastrophizing from pretreatment to posttreatment in adult chronic

pain patients. Three out of ten studies in this review involve patients of non-chronic illnesses, however, the symptom of persistent pain is given in these illnesses too (S8; S9; S10). Thus, the results are expected to be fairly transferable. Those studies were included because of the lack of high quality studies on MBIs' effect on pain catastrophizing in chronic pain patients. Only controlled trials with at least 30 patients in the treatment group, and a minimum of 20 patients in the control group, were included. Additional inclusion criteria were: 1) assessment of pain catastrophizing through either PCS or the catastrophizing subscale of CSQ due to reliability and validity, 2) articles published after 2008 due to up-to-dateness of MBIs, 3) non-specific clinically relevant persistent pain.

Exclusion criteria. In order to be able to draw valid conclusions about the effect of MBIs on pain catastrophizing in chronic pain patients, studies with outcomes for experimentally induced pain or acute pain on nonclinical populations were excluded. Correspondingly, studies on pain catastrophizing outcomes after surgery were excluded as well. Moreover, studies applying mindfulness yoga or non-mindfulness forms of meditation, such as transcendental meditation, were excluded. There were no exclusions of study populations based on gender or pain severity.

All potential studies and references were screened by title and abstract, and those that did not meet eligibility criteria were eliminated. The whole process of online searching, visiting two libraries in Cologne, and one in Bonn, reading abstracts of all potential studies, and rejecting inadequate articles, took about six weeks. Eventually, ten studies for each research question were found by April 15, 2019.

Results

In the upcoming paragraphs, the results of the included studies for the hypotheses will be summarized. The studies are consecutively numbered from S1 to S10 for the first hypothesis, and from S11 to S20 for the second hypothesis. All studies and their characteristics will be illustrated in tables, which can be found in the appendix of this paper. Hypothesis a) and hypothesis b) will be depicted separately to maintain an overview.

Study Selection a)

Hypothesis a) states that pain catastrophizing significantly increases disability and pain intensity in chronic pain patients. Altogether, ten studies that assessed the relationship between pain catastrophizing, and both pain and disability in chronic pain patients, were identified. Details of the included studies are summarized in Table 1 in appendix A. Sample sizes ranged from 47 to 1,571. Five studies employed the PCS (Sullivan et al., 1995), four used the catastrophizing subscale of the CSQ (Rosenstiel & Keefe 1983), and one used both. Three longitudinal study designs and seven cross-sectional study designs are included. The studies measured the pain outcome using a variety of instruments, including the *Visual Analogue Scale* (VAS; Price, McGrath, Rafii, & Buckingham, 1983), the *Graded Chronic Pain Scale* (GCPS; Korff, Ormel, Keefe, & Dworkin, 1992), the *Multidimensional Pain Inventory* (MPI; Kerns, Turk, & Rudy, 1985), the *Arthritis Impact Measurement Scale* (AIMS; Meenan, Gertman, Mason, & Dunaif, 1982), pain items of the *Quebec Back Pain Disability Scale* (QBPDS; Kopec et al., 1995), and one self-constructed questionnaire by the authors of S8. Disability outcomes were measured by AIMS, QBPDS, the *Lysholm Knee Scale* (LKS; Lysholm & Gillquist, 1982), GCPS, the *Roland and Morris Disability Questionnaire* (RDQ; Roland & Fairbank, 2000), disability ratings, and the MPI subscales “life control” and “interference”.

Overview of Study Contents a)

Following this, a general overview of the contents of each study will be given. All exact correlation coefficients, regression coefficients, odds ratios, and significance levels will be illustrated in Table 1 in appendix A. Correlation effect sizes will be labelled as small ($r<0.3$), medium/moderate ($0.3< r <0.5$), or large ($r >0.5$; Cohen, 1988). The studies’ principal objectives and main findings for pain catastrophizing’s relation to pain intensity and disability, as well as conclusions concerning the hypothesis, will be summarized. Table 1 will additionally provide overall major results of each study.

Cross-sectional studies. In S1 (Somers et al., 2009) the purpose was to examine the role of pain-related fear and pain catastrophizing in their relation to pain severity, psychological

disability, physical disability, and walking speed. The study focused on only overweight and obese osteoarthritis (OA) patients, as they experience more intense pain, especially with movement. Further, it was assumed that due to a higher pain experience, they hold negative pain cognitions more often. The results show that pain catastrophizing, which was measured through a subscale of the CSQ, accounts for a significant amount of variance in pain (10%) and physical disability (11%). Of pain catastrophizing and pain-related fear, only pain catastrophizing is a significant independent predictor of pain severity and disability. It was concluded that pain cognitions, particularly pain catastrophizing, need to be addressed to reduce pain and disability in OA patients.

S2 (Peters, Vlaeyen, & Weber, 2005) examined the contribution of physical pathology, pain-related fear, and pain catastrophizing, to pain intensity and disability. The sample was composed of non-specific chronic low back pain (CLBP) patients. The authors included the assessment of physical pathology to prove its insufficient power in predicting pain-related outcomes. The findings demonstrate a significant medium positive correlation between pain catastrophizing and disability ($r=0.33$, $p<0.01$). Furthermore, pain catastrophizing correlates significantly, but lowly, with present pain intensity ($r=0.25$, $p<0.05$). In addition to that, pain catastrophizing significantly adds 6% to the explained variance of pain intensity. However, the PCS does not show a significant contribution to the prediction of disability after regression analysis. The authors suggest that targeting maladaptive cognitions and affective responses to pain may lower levels of pain and disability.

The main objective of S3 (Domenech, Sanchis-Alfonso, Lo´pez & Espejo, 2013) was to examine the participation of kinesiophobia and catastrophizing on present pain and disability of chronic anterior knee pain sufferers. The outcomes show a medium and significant correlation between pain catastrophizing and pain intensity ($r=0.43$; $p < 0.001$). Moreover, pain catastrophizing significantly and negatively correlates with the Lysholm Scale, which measures the patient's ability level, with a large strength (-0.59; $p<0.001$). "Catastrophizing" is the strongest subscale of the CSQ correlating with pain and disability. Catastrophizing explains 19% of pain variance and 28% of disability. The authors emphasized the central role of pain catastrophizing in predicting disability. It was implied that interventions that specifically improve catastrophic thinking in chronic pain patients shall be established.

S6 (Tuner, Jensen, Warms, & Cardenas, 2002) hypothesized that increased pain catastrophizing is related to increased pain intensity, disability, and psychological distress in chronic pain patients with spinal cord injury. In addition to that, the associations between specific coping strategies with the aforementioned pain-related outcomes were examined. The results show that

after controlling for pain intensity and spinal cord injury variables, the CSQ catastrophizing subscale is the only coping mechanism that is significantly and independently related to pain intensity and disability. All in all, the CSQ accounts for additional 29% of the explained variance in pain intensity, and 11% of the variance in pain-related disability. The authors made the conclusion that the treatment of pain catastrophizing in chronic pain patients might result in improved pain outcomes.

In S8 (Severeijns, van den Hout, & Picavet, 2004) the relationships between pain catastrophizing, pain intensity, the number of pain locations, the number of specialist consultations, the use of medication, and work absenteeism/disability, were examined in chronic musculoskeletal pain patients. The outcomes show that there is a significant, though low correlation between PCS scores and pain intensity ($r=0.22$; $p<0.001$). The odds ratio between pain catastrophizing and work disability is significant as well ($OR=1.19$; $p<0.001$). For people with a current episode of pain, catastrophizing is related to higher absenteeism or work disability. It was concluded that patients who catastrophize about pain have more work disability, consult specialists more often and use more medication.

Authors in S9 (Keefe et al., 2000) assessed osteoarthritis patients on pain catastrophizing, depressive symptoms, pain, pain behavior, and physical disability to find gender differences. The findings demonstrate how the pain catastrophizing subscale positively and significantly correlates with disability and pain intensity. A large correlation with pain intensity ($r=0.69$; $p<0.05$), and a large correlation with disability ($r=0.75$; $r<0.05$) is apparent. Besides, pain catastrophizing mediates the relationship between gender and pain outcomes. The authors concluded that gender and catastrophizing are essential in understanding and treating osteoarthritis pain.

The objective of S10 (Severeijns, Vlaeyen, van den Hout & Weber, 2001) was to investigate the association between pain catastrophizing and pain intensity, disability, and psychological distress in chronic pain patients, after controlling for physical impairment. It was hypothesized that catastrophizing is a significant predictor of the aforementioned variables. The following results are interesting for this review: PCS scores show significant medium correlations with disability, which was measured by the Multidimensional Pain Inventory subscales “interference” ($r=0.43$; $p<0.01$) and “life control”($r=-0.47$; $p<0.01$). Furthermore, pain catastrophizing has a medium significant positive correlation with pain intensity ($r=0.3$; $p<0.01$). Catastrophizing significantly adds to the variance of pain intensity ($ß=0.268$; $p<0.01$) and disability (“interference” $ß=0.44$, $p<0.01$; “life control” $ß=-0.47$, $p<0.01$). It was concluded

that pain catastrophizing is a fundamental cognitive variable in predicting the chronic pain experience.

Longitudinal studies. S4 (Domenech et al., 2014) investigated the relation between changes in psychological variables and pain and disability outcomes in chronic anterior knee patients. Pain, disability, kinesiophobia, pain catastrophizing, anxiety, and depressive symptoms were measured at baseline before medical treatment, and at 6-months follow-up after medical treatment. The following results are relevant for this paper: Those patients who had decreases in catastrophizing show higher improvements in pain and disability after the treatment. The changes in catastrophizing predict the reductions in pain severity and disability. Changes in catastrophizing account for 48% of changes of the explained variance of pain intensity, and 56% of disability. Additionally, moderate positive and significant correlations between catastrophizing and pain and disability were found. The authors suggested interventions that reduce maladaptive beliefs, in particular catastrophizing and kinesiophobia, to improve pain and disability outcomes.

S5 (Picavet et al., 2002) analyzed the role of pain catastrophizing and kinesiophobia in low back pain, CLBP, and disability. At both baseline and 6-months follow-up, subjects with and without current low back pain were surveyed. The findings indicate that pain catastrophizing significantly predicts low back pain (OR=1.7; CI= 95%) and disability level (OR=3.0; CI=95%) in CLBP patients at follow-up. The authors suggested an introduction of prevention programs that reduce negative orientations toward pain so that chronification of pain can be prevented.

In S7 (Woby, Watson, Roach, & Urmston, 2004) CLBP patients were assessed before and after a cognitive-behavioral intervention. The authors' aim was to explore whether changes in catastrophizing, Fear-Avoidance beliefs and appraisals of control are associated with changes in pain intensity and disability. It was found that changes in catastrophizing are not significantly related to changes in pain intensity and disability. The authors suggested that CLBP interventions should target cognitive factors associated with improved pain outcomes, namely Fear-Avoidance beliefs about work and physical activity, and perceptions of control over pain.

Overall, significant associations between pain catastrophizing and pain and disability were observed in nine out of ten studies for hypothesis a). The results show significant correlations between pain catastrophizing and pain reaching from r=0.25 to r=0.69. On average, the correlation strength is moderate. Pain catastrophizing's contribution to the explained variance of pain reaches from 6% to 29%, and even 37% in high catastrophizing participants (S6). These are medium to large effect sizes (Cohen, 1988). Results from the studies' hierarchical linear regression analyses show that pain catastrophizing adds up to 28% to the variance of disability,

while in one study there is no significant contribution to disability's variance at all (S2). Significant correlations between pain catastrophizing and disability reach from r=0.33 to r=0.75. On average, both the correlation strengths, and the results for regression analyses, are moderate to large between pain catastrophizing and disability. In two out of three longitudinal studies, changes in catastrophizing significantly predict changes in pain and disability at follow-up, whereas one study shows no relation at all (S7).

Study Selection b)

Hypothesis b) says that mindfulness-based interventions significantly reduce pain catastrophizing scores in chronic pain patients. In order to examine this statement, ten studies were included in the present paper. Six of them are randomized controlled trials, and four studies are controlled trials. Sample sizes for the intervention groups range from 39 to 140. The MBIs include three standard MBSR programs, two standard MBCT programs, while one of them is online, two mindfulness-based chronic pain management programs, two nonspecific mindfulness-based programs, and one mindfulness and acceptance based program. Five studies compared the MBI group to a waiting list, two to an education group, two to a cognitive-based therapy group, and one to a social support group. Four studies focus on nonspecific chronic pain, two on CLBP, one on rheumatoid arthritis, one on irritable bowel syndrome (IBS), one on provoked vestibulodynia (PVD), and one on breast cancer with persistent pain. Altogether, seven out of ten studies examined chronic pain patients, whereas three investigate patients with chronic illnesses that include persistent pain as a major symptom. Pain catastrophizing was assessed by the PCS in five studies, while the other five studies utilized the catastrophizing subscale of the CSQ.

Overview of Study Contents b)

In the upcoming paragraphs each study will be described with reference to hypothesis b). In order to put the articles into a bigger context, the primary objectives of the studies will be briefly pointed out. All exact pre-to-post changes are depicted in Table 2 in appendix B.

S11 (Davis, Zautra, Wolf, Tennen &Yeung, 2015) is a post hoc analysis of the original trial by Zautra and colleagues (2008). They examined the effects of CBT, mindful awareness and acceptance treatment, and arthritis education, and compared the outcomes. The participants, which suffered from rheumatoid arthritis, completed diaries measuring pain, fatigue, pain catastrophizing, perceived control, morning disability, and serene and anxious affects. The mindful awareness and acceptance group achieved the greatest reductions in pain-related

catastrophizing (Time $t = -2.54$, $p < .02$). In periods of high daily pain, only the MBI improved the individual's ability to limit catastrophizing.

S12 (Dowd et al., 2015) compared the effects of a 6 week online mindfulness intervention with a 6 week online pain management psychoeducation. Measures included pain interference, pain intensity, pain catastrophizing, and other psychological and physical variables. Both intervention groups show similar significant improvements in pain catastrophizing and other psychological outcomes, which maintained at 6-months follow-up. The "Mindfulness in Action" group, which is the name of the applied MBI, has an estimated PCS mean score of 14.89 at baseline, 12.93 at post treatment, and 13.28 at follow-up.

S13 (Turner et al., 2016) compared measures of catastrophizing, self-efficacy, acceptance, and mindfulness in three treatment groups composed of CLBP patients. Mindfulness-based stress management, CBT, and usual care were conducted. The results show that catastrophizing was slightly more reduced with MBSR than with CBT at post-treatment. The mean PCS score decreased by about 5.56 scores from baseline to 8 weeks post-treatment ($p=0.002$), which is significant.

S14 (Gardner-Nix, Juliana Barbati, Grummitt, Pukal, & Newton, 2014) examined the effect of a mindfulness-based chronic pain management on chronic pain patients. Quality of life, pain catastrophizing, usual pain levels, and pain-related suffering were assessed before and after treatment, and in a waiting list group. The findings show that the magnification and rumination dimensions significantly decreased from baseline to post-treatment, while rumination approaches significance. Altogether, the PCS scores significantly decreased after the mindfulness intervention for chronic pain patients.

For S15 (Gardner-Nix, Backman, Barbati, & Grummitt, 2008) chronic pain patients participated in either a present site group or distant site group of a 10 week mindfulness-based chronic pain management intervention. Outcome measures included quality of life, pain catastrophizing, and usual pain ratings, which were assessed before and after treatment. In both present and distant site group, the PCS scores decreased significantly by 4 to 5 scores on average.

In S16 (La Cour & Petersen, 2015) chronic pain patients were randomized to either an MBSR program or a wait list control group. Levels of pain, physical function, mental function, pain acceptance, and health-related quality of life, were measured before and after treatment, and at 6-month follow-up. The results show that catastrophic thinking, a subscale of the CSQ, decreased from a mean score of 16.6 pre-treatment to a score of 14.7 post-treatment, but not significantly.

S17 (Morone et al., 2016) investigated the effectiveness of a mind-body program modeled on MBSR, and a health education program in CLBP patients that were 65 years or older. Physical function and pain severity were the primary outcomes to examine. The baseline mean score for the MBI group was 1.3. At 8-week follow-up, the number dropped to 0.9. It rose up to 1.1 at 6-month follow-up. However, these results are not significant.

In S18 (Garland et al., 2012), patients with irritable bowel syndrome were examined before and after they were assigned to a mindfulness training or social support group. The patients received an 8-week mindfulness training and were assessed on IBS-related outcomes such as IBS severity, IBS- quality of life, visceral sensitivity and more. In addition, pain catastrophizing and some facets of mindfulness were measured. The results show that mindfulness training significantly improved pain catastrophizing outcomes in the treatment group. The mean score decreased by 3.5 ($p<0.01$).

In S19 (Brotto, Basson, Smith, Driscoll, & Sadownik, 2014), women with provoked vestibulodynia were examined on pain-related endpoints, sex-related endpoints, and mood-related endpoints, after a mindfulness-based four-session group treatment, or a waiting list. The results show that all the dimensions of the PCS, namely rumination, magnification and helplessness, decreased significantly between pre-treatment and post-treatment, and from post-treatment to follow-up. The exact scores are displayed in Table 1.

S20 (Johannsen, O'Toole, O'Connor, Jensen, & Zachariae, 2018) examined potential mediators of MBCT on pain intensity in breast cancer patients with persistent pain. Variables measured were mindfulness, self-compassion, and pain catastrophizing, in both treatment group and wait-list control. At baseline, the patients had a PCS mean score of 18.5. At post-treatment, the mean score dropped to 10.7, which is a significant decrease. Additionally, pain catastrophizing explains 78% of the effect of MBCT on pain intensity as the only significant mediator.

In brief, out of ten studies, eight show a significant decrease in pain catastrophizing from pretreatment to posttreatment. Seven of these studies report an improvement in catastrophizing that is significantly higher than that observed in the comparison groups. In one study, the decrease in PCS is insignificantly higher than the CBT comparison group (S11). In S13, the MBI achieved significantly better improvements in pain catastrophizing than the CBT. All in all, two out of ten studies did not observe any significant difference in catastrophizing outcomes for the MBI group at any time (S16; S17).

Discussion

In the first part of the present thesis, the existing literature was systematically reviewed on the association between pain catastrophizing and pain and disability in chronic pain patients in order to examine the causal pathway the FAM proposes. Significant moderate to large associations between pain catastrophizing and pain and disability were reported in the examined studies. In the second part of this thesis, the literature was reviewed on the effect of MBIs on pain catastrophizing in chronic patients. All in all, the studies suggest that MBIs reduce pain catastrophizing with medium effect sizes on average. Results from four follow-up studies (S13; S15; S19; S20) indicate that pain catastrophizing reductions were maintained over 6-month follow-up periods. It is notable that all of the studies for hypothesis a), which says that pain catastrophizing increases disability and pain among chronic pain patients, specifically looked for an association between pain catastrophizing and pain and disability, and proposed hypotheses with regard to the FAM. On the other hand, the studies for hypothesis b), which states that MBIs reduce pain catastrophizing in chronic pain patients, laid their focus on changes in other factors, such as changes pain intensity after mindfulness interventions. This illustrates the lack of research on the mechanisms involved in the effects of MBIs on pain-related outcomes in chronic pain patients. There is only limited evidence that suggests specific mediators, because most studies mainly investigate changes in pain, depressive symptoms, or quality of life (Hilton et al., 2016). Thus, the present paper is the first to take up this issue and focus on MBIs influence on pain catastrophizing as a key mechanism. However, one of the included studies for hypothesis b) does include pain catastrophizing as a possible mediator (S20). The authors stated that it mediates the effect of the MBI on pain intensity. Due to the findings that pain catastrophizing is related to heightened pain intensity and disability, there are grounds to assume that the effects of MBIs on pain and disability, which are shown by several studies (S11; S17; Chiesa & Serretti, 2011), are mediated by the reductions in pain catastrophizing. A study demonstrated that pain catastrophizing is related to disability even stronger than pain intensity (Swinkels-Meewisse, Roelofs, Oostendorp, Verbeek, & Vlaeyen, 2006). However, S2 discovered that pain intensity is the best predictor for disability. It is possible that the effect of pain catastrophizing on disability is mediated by reductions in pain intensity. This needs to be researched further as well.

Results in the Light of existing Literature

Theories that may explain the results of this review were already presented earlier when the research question was explained. Therefore, this section will discuss the existing studies that may serve as alternative explanations for the results.

The first essential factor that might explain the result for hypothesis b) is increased acceptance. Brown and Jones (2010) assumed that reduced pain in long-term meditators might stem from increased acceptance. Respectively, a study found that acceptance of pain improves important aspects of emotional and physical functioning in chronic pain patients (McCracken & Vowles, 2006). In fact, S12 shows that acceptance scores improved after the MBI. Acceptance and catastrophizing correlate negatively, as S13 found. Therefore, heightened acceptance might be a mediating variable between MBIs and reductions in catastrophizing. Another relevant factor is fear. The FAM proposes that pain-related fear stems from pain catastrophizing. Fear of pain is based on classical conditioning and causes safety-seeking behavior, such as avoidance or escape, which leads to rest time and heightened disability (Vlaeyen & Linton, 2000). In 1993, McCracken and Gross discovered a significant correlation between the catastrophizing scale of the CSQ and scores of the Pain Anxiety Scale (McCracken, Zayfert., & Gross, 1992). Crombez et al. (1998) found that a non-clinical sample with frequent pain-related catastrophic thinking became more fearful when threatened with possible pain than the individuals with low catastrophizing. Nevertheless, there is only little research specifically investigating the association between pain catastrophizing and pain-related fear. It is apparent that it is unclear whether pain catastrophizing is the precursor of fear, or the other way round, and which of these two variables predict pain and disability more accurately. There is literature that provides an indication: In an experimental pain study, pain-related fear is a stronger predictor of pain outcomes than catastrophizing (Hirsh, George, Bialosky, & Robinson, 2008). Similarly, a study on chronic low back pain patients found that kinesiophobia, which is the fear of movement, is a better predictor of disability than pain catastrophizing (Crombez et al., 1999). One of the included studies (S2) claimed that fear of movement/ (re)injury proved to be a better predictor than catastrophizing as well. On the contrary, S1 demonstrated that pain catastrophizing plays a bigger role in the prediction of pain and disability than pain-related fear. It is important to know which of these two factors predict pain-related outcomes more strongly, as they might be addressed differently in therapy. For instance, fear is usually approached by in vivo exposure. As a matter of fact, Baer (2003) suggested that MBIs serve as in vivo exposure, as they involve motionless sitting that exposes patients to pain sensations in the absence of catastrophic consequences. Thus, MBIs might address fear, too.

As can be seen, there are several assumptions and theories concerning the mechanisms involved in the effect of MBIs on pain catastrophizing. These other potential mechanisms in MBIs, in particular increased acceptance and reduced fear, need to be considered in future research.

Limitations

Most of the articles in the present paper indicate that pain catastrophizing predicts pain and disability level, and that it should be targeted in chronic pain interventions. Nonetheless, a number of limitations were observed that may influence the interpretations of the findings for hypothesis a). First of all, a cross-sectional design precludes any causal assumptions from being made. Therefore, it is impossible to determine the true cause-effect relation between pain catastrophizing and outcomes. In spite of the assumptions at the beginning of this paper, that it is likely that catastrophizing precedes chronic pain, one might also argue that pain catastrophizing is the consequence of chronic pain. Longitudinal studies do not allow definitive judgements on this matter either, since the converse cause-effect relation is possible, too. It is striking that most studies presume that pain catastrophizing is the cause for increased pain intensity and disability, and not the other way round (Sullivan et al., 2001; Quartana et al., 2009). However, a cross-lagged panel study showed that early-treatment of catastrophizing and pain helplessness change predicted treatment outcomes, but not vice versa, in chronic pain patients (Burns, Kubilus, Bruehl, Harden, & Lofland, 2003). Another limitation is that approximately 80% of the samples for hypothesis a) are females. Thus, the link between pain catastrophizing and outcomes might be more accurate for females. In fact, a study examined gender differences in catastrophizing and determined that for females, pain catastrophizing significantly predicts pain and pain behavior, whereas for men, pain catastrophizing does not contribute to the outcomes in experimentally induced pain (Sullivan, Tripp, & Santor, 2000). Eventually, all studies rely on self-report questionnaires or retrospective questions to assess the variables. Very often this comes along with biases, such as social desirability. Especially for pain catastrophizing and pain-related outcomes, it is possible that patients exaggerate symptoms to make their pain seem worse, perhaps to gain compassion or please the instructor, or, on the contrary, attempt to minimize the severity of their problems. Apart from that, one can simply misremember information covered by the questionnaire. This limitation applies to hypothesis b), too.

Evidence for hypothesis b) is limited as well. Four out of ten studies for hypothesis b) were not randomized (S11; S14; S15; S19), which can result in a selection bias within those studies. Apart from that, six out of ten studies focus on a particular illness, which makes it unclear to what extent the results are generalizable to other chronic pain conditions. Equally important,

there was no verification of the clinicians' competence, which might influence internal validity. Another important limitation is the difference in techniques, lessons, homework, and duration of the MBIs in the included studies. On the whole, five of the studies did not apply standardized MBIs. Therefore, this review cannot provide a precise estimate on the efficacy of a standardized MBI. Referring to this, a recent study has shown that the length of a mindfulness program does not significantly influence the outcome (McGrady & Moss, 2018). One of the included studes (S11) implemented a "mindful awareness and acceptance treatment", which is why it is unclear to which extend acceptance might be the reason for the results. Further, similar to hypothesis a), generalizability to males might be limited since the samples for hypothesis b) primarily consist of females: roughly 75% in studies from S11 to S17, and 100% in S18, S19, and S20. Interestingly, Sullivan and colleagues (1995) observed that women catastrophize more than men. Beyond that, most subjects belong to western countries, which may interpret mindfulness differently than eastern populations. It is also important to note that three studies of hypotheses b) may not count as fully representative, since the conditions are chronic illnesses, and not chronic pain conditions. One might argue that they do not include psychological aspects to the same extent as chronic pain illnesses, because the tissue damage is more dominant. Nevertheless, psychological factors contribute to those illnesses as well. For instance, a study found out that attention biases play a large role in IBS (S18; Whitehead & Palsson, 1998). In breast cancer patients (S20), coping strategies are partly responsible for the physical and psychological adjustment, as a study found (Stanton et al., 2000). Another study stated that Fear-Avoidance beliefs predict treatment outcomes in women with PVD (S19; Desrochers, Bergeron, Khalifé, Dupuis, & Jodoin, 2010). Therefore, the transferability of these results is not questioned. Finally, one limitation which applies to both hypotheses is that the pain catastrophizing construct is defined differently in the studies: the catastrophizing subscale of the CSQ focuses on only intolerable thoughts, while the PCS assesses several aspects of catastrophic thinking about pain.

As with all reviews, despite a thorough and exhaustive search process, some studies and data on this topic may have been missed. Title and abstract screening were carried out by one reviewer, and has not been revised by a second reviewer. Additionally, it is important to be aware of the publication bias, where studies with significant results are more likely to be published than those that do not provide significant results (Drucker, Fleming, & Chan, 2016).

Implications for Research and Practice

For hypothesis a) there is a need for longitudinal randomized experimental studies with interventions that manipulate levels of pain catastrophizing and examine the effects of this manipulation on pain and disability variables. Future studies should include more objective measures of pain-related outcomes, such as behavioral measures, ratings by clinicians, and psychophysiological and neuroimaging measures, to counter biases, such as social desirability. The PCS should be the standard assessment tool for pain catastrophizing, since it assesses more dimensions of the construct. Additional large-scale RCTs that use standardized MBIs, in particular MBSR or MBCT, are needed to extend current findings for hypothesis b). Aside from that, it is possible that MBIs might affect important mediators that haven't been assessed by the included studies. In order to find out what mechanisms are involved in the efficacy of MBIs in improving pain catastrophizing, further research is necessary to clarify the constructs involved, and how they are related to each other. For instance, attention shift, increase in acceptance, or decrease in fear could be involved as potential mediating factors as well. As already mentioned earlier, there are only few studies that examine the relationship between pain catastrophizing and fear, as noticed during research. A better understanding of the therapeutic mechanisms influencing these outcomes could improve psychological treatments. This review's results highlight the need for further research on the mediating variables of MBIs on pain intensity and disability. There is also a need for more research on the efficacy of the other available treatments on pain catastrophizing. Even though MBIs seem to improve pain catastrophizing moderately, there is no sufficient evidence to determine whether MBIs are more effective in decreasing pain catastrophizing than other interventions, such as CBT, ACT, or physical therapies. Concerning this matter, a study from 2006 investigated the mediating effect of changes in pain catastrophizing on treatment outcomes for CBT and physical treatment. The results show that both interventions reduce pain catastrophizing, and that these reductions seem to mediate the improvements in pain and disability in CLBP patients (Smeets, Vlaeyen, Kester, & Knottnerus, 2006). What is also notable is that in S12, the psychoeducation control group achieved similar results in the reduction of pain catastrophizing as the MBI group. Further research needs to be done in order to find the most effective treatment for the reduction of pain catastrophizing in chronic pain patients. From a clinical perspective, the findings of the present study could be used to modify existing interventions so they specifically improve cognitive appraisals and pain catastrophizing in chronic pain patients. Since the FAM does not only describe the persistence of chronic pain, but also the chronification process from acute pain to chronic pain, early interventions can serve as preventions. Targeting catastrophizing during treatment can produce

clinically relevant reductions in disability and pain intensity in chronic pain. Additionally, clinicians need to consider the social context of catastrophizing. It can have desirable interpersonal consequences, as the Communal Coping Model states (Sullivan et al., 2001). Empathy and supportive reactions from spouses, for example, might even reduce pain and helplessness, and serve as coping resource (Holtzman & DeLongis, 2007). It might be helpful to find alternative interpersonal approaches to communicate their need for support.

On the whole, the present thesis provides an important insight into some psychological mechanisms involved in the chronic pain experience. It makes clear that chronic pain is not only a biological problem. As a matter of fact, studies show that physical impairment does not sufficiently explain pain-related outcomes (S10; Waddell, Somerville, Henderson, & Newton, 1992). It is essential to draw attention to cognitive and emotional aspects of chronic pain, apart from organic factors, in the treatment of chronic pain patients.

Conclusion

This review demonstrates evidence for the association of pain catastrophizing with disability and pain among adult chronic pain patients with moderate to large effect sizes. Yet, there are insufficient longitudinal studies to determine the true causal pathway between pain catastrophizing and these variables, since the majority of the studies is cross-sectional. Aside from that, there is little empirical evidence available on MBIs' effect on pain catastrophizing in chronic pain patients. Nevertheless, the included studies suggest significant improvements in pain catastrophizing outcomes among chronic pain sufferers enrolled in an MBI compared to control. Yet, the findings of this review for the positive effect of MBIs on pain catastrophizing have to be interpreted with caution due to small sample sizes and absence of randomization. Further randomized large-scale studies with standardized MBIs, preferably MBCT or MBSR, are needed to extend current findings. Notwithstanding these limitations, the results suggest a potential clinical usefulness of MBIs in decreasing pain catastrophizing. There are grounds for supposing that the reduction in pain catastrophizing is related to reductions in pain and disability in chronic pain patients. The findings of this review can increase awareness of practitioners and health care professionals so that they consider MBIs as an intervention for adults with chronic pain conditions. However, meditation does not suit every patient in the same way. It involves a change in daily schedules, which needs motivation and commitment. After all, this review is adding to the growing body of literature on MBIs for chronic pain. This thesis is the first study to suggest reductions in pain catastrophizing as the key underlying mediating mechanism for the positive effect of MBIs on pain and disability in chronic pain patients.

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Appendix A

Table 1. Characteristics of Included Studies: Hypothesis a)

ID	Study; Country; Design	Condition	Sample Size	Tools: Pain Catastrophizing; Pain Intensity, Disability	Relationship between Pain Catastrophizing and Pain Intensity / Disability	Overall findings
S1	Somers et al., 2009; USA; Cross-sectional	Osteoarthritis	N= 106	Catastrophizing subscale CSQ; The Arthritis Impact Measurement Scales (AIMS) : pain and physical disability scales	Catastrophizing explains significant variance in measures of pain (partial $r^2[pr^2] = 0.10$) and physical disability ($pr^2 = 0.11$; all p's < 0.05) ➔ Significant	Pain catastrophizing explains significant proportions of pain, psychological disability, physical disability, and walking speed
S2	Peters et al., 2005; The Netherlands; Cross-sectional	Chronic low back pain	N= 100	PCS; Visual Analog Scale (VAS) for present pain; Quebec Back Pain Disability Scale (QBPDS)	r (PCS; VAS) =0.25 ($p<0.05$); r (PCS; QBPDS) =0.33, ($p<0.01$); PCS adds 6% to variance of pain intensity; PCS does not significantly contribute to variance of disability ➔ Significant	Age and fear of pain are the strongest predictors of pain intensity; Pain intensity is the strongest predictor of disability

Table 1. (continued)

ID	Study; Country; Design	Condition	Sample Size	Tools: Pain Catastrophizing; Pain Intensity, Disability	Relationship between Pain Catastrophizing and Pain Intensity / Disability	Overall findings
S3	Domenech et al., 2013; Spain; Cross-sectional	Chronic anterior knee pain	N= 97	PCS; VAS; The Lysholm Knee Scale (LKS)	r (PCS; VAS) =0.43, ($p<0.001$) r (PCS; LKS) =-0.59, ($p<0.001$) Catastrophizing explains 19% of Pain variance/37% in high responders; and 28% of disability ➔ Significant	Catastrophizing and kinesiophobia significantly predict pain and disability ; Pain level is not significantly correlated to disability; Depression scores significantly predict pain and disability
S4	Domenech, et al., 2014; Spain; Longitudinal	Chronic anterior knee pain	N= 47	PCS, Catastrophizing subscale CSQ; VAS; LKS	r (VAS [T1]; Catastrophizing) =0.48; r (VAS[T2]; Catastrophizing) =0.50; r (LKS [T1]: Catastrophizing)=0-62¸; r (LKS [T2]: Catastrophizing)=0-50; r (VAS [T1]; PCS) = 0.47; ; r (VAS [21]; PCS) = 0.49; r (LKS[T1]; PCS)=-0.59; r (LKS[T2]; PCS) =-0.57; All $p<0.001$; Changes in catastrophizing account for 48% of R^2 in changes of pain and 56% in changes of disability ➔ Significant	Changes in catastrophizing predict changes in pain and disability; Catastrophizing is positively related to pain intensity and disability at baseline and follow-up; Reduction in kinesiophobia shows moderate correlation with disability improvements and low correlation with pain improvements

Table 1. (continued)

ID	Study; Country; Design	Condition	Sample Size	Tools: Pain Catastrophizing; Pain Intensity, Disability	Relationship between Pain Catastrophizing and Pain Intensity / Disability	Overall findings
S5	Picavet et al., 2002; The Netherlands; Longitudinal	Chronic low back pain	N= 1, 571	PCS; Items of Quebec Back Pain Disability Scale (QBPDS) for current low back pain (LBP) and LBP with disability; items on LBP limitation, Severe LBP, CLBP	High PCS predicts current LBP and CLBP (both odds ratio (OR) = 1.7) ; LBP limitation (OR=3.7); severe LBP and LBP with disability (both OR=3.0) at follow-up all 95% confidence interval ➔ Significant	For those with and without LBP at baseline, pain catastrophizing predicts pain and disability at 6-months follow-up
S6	Turner et al., 2002; USA; Cross-sectional	Chronic pain after spinal cord injury	N=174	Catastrophizing subscale CSQ; Graded Chronic Pain Scale (GCPS) for both pain intensity and disability	CSQ adds 29% to variance of pain intensity, subscale "Catastrophizing" is the only significant subscale: unstandardized regression coefficient (B)= 6.34, $p<0.001$; CSQ adds 11% to variance of disability; Catastrophizing is the only significant subscale (B=1.89; $p<0.001$) ➔ Significant	Pain coping and catastrophizing explain 29% of variance in pain intensity; 30% of variance in psychological distress, 11% of variance in pain-related disability; Catastrophizing is the only coping strategy that is independently associated with the outcome measures

Table 1. (continued)

ID	Study; Country; Design	Condition	Sample Size	Tools: Pain Catastrophizing; Pain Intensity, Disability	Relationship between Pain Catastrophizing and Pain Intensity / Disability	Overall findings
S7	Woby et al., 2004; UK; Longitudinal	Chronic low back pain	N=54	Catastrophizing subscale of CSQ; VAS ; Roland and Morris Disability Questionnaire (RDQ)	Standardized regression coefficients ß: Pain intensity (dependent variable) and Catastrophizing ß=0.23; Disability (dependent variable) and Catastrophizing ß=0.10 ➔ Not significant	Reductions in fear-avoidance beliefs about work and physical activity + increased perceptions of control over pain are significantly related to reductions in disability; Changes in cognitive factors are not significantly related to changes in pain intensity
S8	Severeijns et al., 2004; The Netherlands; Cross-sectional	Chronic musculoskeletal pain	N= 1,164	PCS; Survey Questionnaire with pain intensity and disability ratings	Current pain group: r (PCS; Pain intensity)= 0.22 ($p<0.001$); Odds ratio of catastrophizing with work disability as dependent variable = 1.19 ($p<0.001$) ➔ Significant	In the group with current episode of pain, pain catastrophizing, pain intensity, and the presence of multiple pain locations are significantly associated with specialist consultation, use of pain medication, and absenteeism or work disability

Table 1. (continued)

ID	Study; Country; Design	Condition	Sample Size	Tools: Pain Catastrophizing; Pain Intensity, Disability	Relationship between Pain Catastrophizing and Pain Intensity / Disability	Overall findings
S9	Keefe et a., 2000; The Netherlands; Cross-sectional	Osteoarthritis	N= 168	Catastrophizing subscale CSQ; Arthritis Impact Measurement Scale (AIMS) for both pain and disability	r (Catastrophizing; Pain intensity)=0.69 ($p<0.05$) r (Catastrophizing; Disability) = 0.75 ($p<0.05$) ➔ Significant	Catastrophizing mediates the relationship between gender and pain-related outcomes; Women experience significantly more pain, disability and pain behavior
S10	Severeijns et al., 2001; The Netherlands Cross-sectional	Nonspecific chronic pain	N= 211	PCS; Multidimensional Pain Inventory (MPI); "life control" and "interference" subscales MPI for disability	r (PCS; MPI)= 0.299 ($p<0.01$) r (PCS; Interference)=0.434 ($p<0.01$) r (PCS; life control)= -0.475 ($p<0.01$) PCS significantly predicts MPI (ß=0.268; $p<0.01$) Interference(ß=0.439; $p < 0.01$) Life control (ß= -0.466; $p < 0.01$) ➔ Significant	Catastrophizing is a predictor of pain intensity, disability, and psychological distress; No group differences between chronic pain subgroups; Gender predicts pain intensity; Women experience more pain; No correlation between catastrophizing and objective physical impairment;

Table 2. Characteristics of Included Studies: Hypothesis b)

ID	Study; Country; Design	Condition	Treatment, Sample Size	Comparator, Sample Size	Assessment Pain Catastrophizing	Assessment Time Points	Findings Pain Catastrophizing MBI	Overall Findings
S11	Davis et al., 2015, USA; CT	Rheumatoid arthritis (RA)	Mindful awareness and acceptance treatment (M) N= 47	CBT for Pain (CBT-P) N=42; Arthritis Education (E) N=44	Rating 1-5 for two pain catastrophizing statements of CSQ	T1: baseline T2: 8 weeks	Pre-to-post improvement time t= -2.54 ($p<0.02$) ➔ Significant	M achieved greater reductions in catastrophizing, disability, fatigue, anxious affect than CBT-P and E
S12	Dowd et al., 2015; Ireland; RCT	Nonspecific chronic pain	Mindfulness In Action (MIA; Online MBCT) N=62	Online psychoeducational program, N=62	PCS	T1: baseline T2: 6 weeks T3: 6 months	Estimated means: T1: 14.89 T2: 12.98 T3: 13.28 ➔ Significant	Interference, acceptance, catastrophizing improve for both groups; MIA better in life satisfaction, emotion management, present pain

Table 2. (continued)

ID	Study; Country; Design	Condition	Treatment, Sample Size	Comparator, Sample Size	Assessment Pain Catastrophizing	Assessment Time Points	Findings Pain Catastrophizing MBI	Overall Findings
S13	Turner et al., 2016; USA; RCT	CLBP	MBSR N= 116	CBT N= 112 Usual Care N=113	PCS	T1: baseline T2: 8 weeks T3: 26 weeks T4: 52 weeks post-treatment	Adjusted mean change from baseline T2: -5.56 (p=0.002) T3: -5.17 (p=0.59) T4: -5.68 (p=0.001) ➔ Significant	Catastrophizing decreases more with MBSR; no long-term effects on trait mindfulness; acceptance, and self-efficacy increase in both groups
S14	Gardner-Nix et al., 2014; Canada; CT	Nonspecific chronic pain	Mindfulness-Based Chronic Pain Management N=60	Wait list N=59	PCS	T1: baseline T2: 10 weeks	Residual Change Scores [F(1.90)] Magnification =8.73, p=0.004; Helplessness =11.19, p=0.001; Rumination = 05.91, p=0.017; ➔ Significant	Mindfulness group shows significant improvements in mental health, pain catastrophizing, and suffering levels

Table 2. (continued)

ID	Study; Country; Design	Condition	Treatment, Sample Size	Comparator, Sample Size	Assessment Pain Catastrophizing	Assessment Time Points	Findings Pain Catastrophizing MBI	Overall Findings
S15	Gardner-Nix et al., 2008; Canada; CT	Nonspecific chronic pain	Mindfulness-Based Chronic Pain Management Present site group N: 99 Distant site group N: 57	Wait list N= 59	PCS	T1: baseline T2: 10 weeks	Means Present site T1: 25.9 T2: 21.1 Distant site T1: 27.7 T2: 22.3 ➔ Significant	Present and distant group show similar results in mental health, catastrophizing, Present group has better results in quality of life and usual pain
S16	La Cour & Petersen, 2015; Denmark; RCT	Nonspecific chronic pain	MBSR N= 54	Wait list N=55	Catastrophizing subscale of CSQ	T1: Baseline T2: 8 weeks T3: 6 months	Means T1: 16.6 T2: 14.7 T3: 14.9 ➔ Not significant	MBSR high significant effects on pain acceptance; vitality, being in control of pain, and general anxiety

Table 2. (continued)

ID	Study; Country; Design	Condition	Treatment, Sample Size	Comparator, Sample Size	Assessment Pain Catastrophizing	Assessment Time Points	Findings Pain Catastrophizing MBI	Overall Findings
S17	Morone et al., 2016; USA; RCT	CLBP	MBSR N= 140	Health education N=142	Catastrophizing subscale CSQ	T1: baseline T2: 8 weeks T3: 6 months	Means T1: 1.3 T2: 0.9 T3: 1.1 Effect Size: T2: - 0.19 T3: 0.5 ➔ Not significant	MBSR group improvements in physical function on short-term, long-term in current and most severe pain
S18	Garland et al., 2012; USA; RCT	IBS	Mindfulness Training (MT) N= 39	Social support group N=38	Catastrophizing subscale of CSQ	T1: pre-treatment T2: 4-6 weeks post-treatment T3: 6 months	Pre-post treatment change mean : -3.5 ($p<0.01$) ➔ Significant	MT improves quality of life, IBS severity, catastrophizing , non-reactivity, visceral activity

Table 2. (continued)

ID	Study; Country; Design	Condition	Treatment, Sample Size	Comparator, Sample Size	Assessment Pain Catastrophizing	Assessment Time Points	Findings Pain Catastrophizing MBI	Overall Findings
S19	Brotto et al., 2014; Canada; CT	Provoked Vestibulo-dynia	Mindfulness-Based program N= 62	Wait list N= 23	PCS	T1: pre-treatment T2: 4-6 weeks post-treatment T3: 6 months	Rumination T1: 9.1; T2: 7.29 T3: 5.35 Helplessness T1:12.6; T2: 9.63 T3: 7.04; Magnification T1:3.13; T2: 2.33 T3: 1.9 ➔ Significant	MBI improvements in pain self-efficacy, catastrophizing, pain vigilance, sexual distress and depressive endpoints
S20	Johannsen et al. ,2018; Denmark, RCT	Breast cancer with persistent pain	MBCT N= 67	Wait list N= 62	PCS	T1: baseline T2: 8 weeks T3: 3 months T4: 6 months	Means T1: 18.5 T2: 10.7 T3: 10.5 T4: 10.6 ➔ Significant	Non-reactivity and catastrophizing show indirect effects of MBCT on pain intensity