A meta-analysis to establish the construct validity and normative values of the Pain Catastrophising Scale

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The candidate confirms that the work submitted is her own and that appropriate credit has been given where reference has been made to the work of others.

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Abstract

Introduction: Outcome measures in clinical psychology tend to be developed in an ad-hoc way, with psychological constructs added to theoretical understanding without formal evaluation of their validity and relationship with existing constructs. Pain catastrophising is an example of a construct with no proven differentiation from other pain-related cognitions. The Pain Catastrophising Scale (PCS) is widely used and several theories exist regarding its theoretical basis and causal relationship with pain outcomes.

Aims: This thesis aims to establish psychometric properties for the PCS from a wide and varied population; to assess the sensitivity of the scale and create norms for pain types; and assess the construct validity of pain catastrophising.

Method: A systematic review was conducted to collect baseline PCS scores from research studies since its development in 1995 to the present day. Meta-analysis including multivariate regression explored variables influencing pain catastrophising. Correlations between the PCS and other measures were used to evaluate the construct validity of pain catastrophising.

Results: Good internal reliability (α=.92, 95% CI .91-.93) and test-retest reliability scores (Spearman correlation coefficient=.88, 95% CI .83-.93) were found for the PCS. Participants' pain type was highly related to PCS scores, with those with generalized pain scoring highest. No significant effects of age or gender were found. Language of the PCS affected PCS scores. Study type influenced PCS scores, but was confounded with pain diagnosis, with controlled trials more likely than quasi-experimental studies to recruit clinical samples. Divergent validity of the construct of pain catastrophising was tentatively supported by limited data.

Discussion: Within the limits of available data, the use of the PCS is supported as a valid and reliable measure. Pain catastrophising varies depending on the pain type and intensity experienced. Further research is recommended to clarify the construct validity of pain catastrophising through consistent use of outcome measures.

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Introduction

This introduction provides an overview of the development of the concept of pain catastrophising, of its relation to other pain-related constructs, and the development and validation of the Pain Catastrophising Scale. The first part of the chapter gives a broader introduction to pain as a construct and its place within clinical psychology.

Defining and categorising pain

Pain is defined as an 'unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage' (International Association for the Study of Pain, 2011, p. 226). The experience of pain is described as subjective and potentially psychological in nature, given that pain is often reported 'in the absence of tissue damage' (IASP, p.226). The recommendation from this source is that if an individual 'regard[s] their experience as pain and if they report it in the same ways as pain caused by tissue damage, it should be accepted as pain' (IASP, p.226). This suggests that the experience of pain is more complex than simply a response to damage to the body. The experience of pain is instead influenced by additional factors including psychological conditions.

Woolf (2010) has classified pain as three distinct categories. The first is nociceptive pain: the sensing of noxious (or harmful) stimuli, creating an unpleasant sensation which functions to protect the individual by motivating them to minimize contact with the stimuli. Inflammatory pain is experienced following an injury, with the function of discouraging physical contact and movement to create better conditions for recovery. These first two categories are considered adaptive as they serve to protect the individual from pain or promote healing and recovery; functions supported by observations that people with congenital insensitivity to pain often die by early adulthood, most likely as a result of failing to notice and respond to illness and injury (Nagasako, Oaklander, & Dworkin, 2003). Lastly, pathological pain is maladaptive and a result of a dysfunctional nervous system. This type of pain has no advantage as it is not protecting against a noxious stimulus or promoting healing. Chronic pain, for example, is frequently

categorized as a pathological pain because the experience of pain is occurring without associated tissue damage.

Prevalence and societal and economic costs of pain

As an example of the costs of pain on services and employment, in the US pain accounts for 'approximately 80% of physician visits and an estimated US$100 billion annually between healthcare expenditures and lost productivity' (Quartana, Campbell, & Edwards 2009, citing Gatchel, Peng, Peters, Fuchs, & Turk, 2007). Chronic pain is reportedly associated with great economic costs and a high impact on the individual's life, as well as with a high rate of suicide (Tang & Crane, 2006). Back pain represents half of all chronic pain. In the UK, back pain alone costs the NHS £1.3 million per day (NHS Careers, 2012). These statistics demonstrate the high impact of pain on society and economics. There has been debate surrounding the prevalence of chronic pain across the lifespan, with Verhaak, Kerssens, Dekker, Sorbi and Bensing (1998) reporting from a review of participants age 18-75 that the prevalence of chronic pain increases with age. In contrast, a more recent European telephone survey by Breivik Collett, Ventafridda, Cohen, and Gallacher (2006) found that chronic pain was equally prevalent in younger and older people.

Historical concepts of pain

Early theories of pain defined it as an emotion (posited by Aristotle: see Dallenbach, 1939) or a punishment from God experienced outside of the body (see Meldrum, 2003). Descartes' theory of pain was of a physical sensation resulting from tissue damage (Descartes, 1972 [1664]). More recent models of pain position its perception as being dependent on the context in which it arises. Beecher's World War Two study found levels of pain expected from the amount of tissue damage were mitigated by 'the imagined benefits of being removed from danger', in that soldiers whose injuries caused them to be removed from the battlefield reported less pain than expected from the injuries they had sustained (Purves et al., 2001 p.219, reporting Beecher, 1946). Later theories of pain make reference to physiological characteristics. Melzack and Wall's Gate Control Theory of pain modulation (1965) refers to the ability to 'reduce the sensation of sharp pain by activating low-threshold mechanoreceptors' (through rubbing the site of injury). A physiological explanation is given that 'the flow of nociceptive

information through the spinal cord is modulated by concomitant activation of the large myelinated fibers associated with low-threshold mechanoreceptors' (reported in Purves et al., 2001, p.220). Further models of pain cite interpersonal influences such as pain responses as a learned attachment behaviour to provoke care from others (Bowlby, 1988, in Mikail, Henderson, & Taska, 1994); and suggest that definitions, expression and experience of pain may vary culturally (Free, 2002). Modern theories of pain perception therefore incorporate sensory, emotional, cognitive-evaluative, interpersonal, and cultural factors.

The psychological impact of pain

As suggested above, it is widely accepted that the experience of pain is modulated by psychological and social factors as well as physical factors. Morley (2008) divides the psychological pain experience into three categories of interruption, interference and identity. Interruption describes the impact of pain on attention and disruption to activities; interference describes the inability to complete tasks to an expected standard; and identity describes the individual's changed sense of who he or she is and his or her ability to achieve future life goals. Interaction between these themes is demonstrated, for example, by an individual experiencing pain that distracts him or her from attending to activities and tasks such that they are not completed to expected standards, resulting in changes to life goals and social status that impact on his or her sense of self. Although interlinked, Morley points out that the distinct categories can be targeted by different treatments. For example methods of optimising attention can be used to address 'interruption'; behavioural management to restore functional capacity for 'interference'; and changes to the individual's relationship with pain and capacity to live according to life values to enhance 'identity'. The psychological impact of pain has been categorized variously by other authors, for example, Eccleston (2001) refers to the role of 'avoidance of pain', which overlaps greatly with Morley's category of 'interference' in its role in changing behaviour to attempt to control pain rather than achieve other valued life goals. Despite differences in categorization and definitions, explanations of the psychological impact of pain appear to have in common the acknowledgement of an interplay between the physical experience of pain, psychological experience, and behavioural response which differ between individuals.

Outcome measures in psychology: validity and reliability

The first part of the introduction above highlighted the existence of psychological factors related to the experience of pain that can be targeted in psychological therapy. In recent years, there has been growing evidence of the use of outcome measures in psychotherapy research (Ogles, Lambert, & Fields, 2002) and in clinical practice (Hatfield & Ogles, 2004) to establish characteristics of an individual's psychological experience and measure change in his or her experience over time. This second part of the introduction considers the use of self-report measures in clinical psychology and associated methodological issues in more detail.

Self-report measures in clinical psychology

Self-report measures or instruments can determine levels of psychological wellbeing or illness that might be targeted during psychological therapy, with examples including the Beck Depression Inventory (Beck, Ward, Mendelson, Mock, & Erbaugh, 1961) and the Obsessive-Compulsive Inventory (Foa, Kozac, Salkovskis, Coles, & Amir, 1998). Measures used in clinical psychology are typically self-report questionnaires or therapist-reported interviews. The purpose of questionnaire-based measurements is to allow 'between-individual comparisons (often in order to determine the magnitude of an individual's experiences) and allowing intra-individual comparisons across time, such as pre- and post-therapy measures' (British Association of Counselling and Psychotherapy [BACP], 2015). Patient-reported outcome measures (PROMs) are incorporated into clinical services in the UK by, for example, being used to determine service outcomes under a payment-by-results system of healthcare commissioning (Black, 2013). Suggestions have been made about how to maximise the impact of PROMs on clinical decision making (Greenhalgh, Long, & Flynn, 2005), for which accurate and well-normed measures would be needed. Arguments have been made for increased routine use of outcome measures in clinical practice for the purpose of 'tracking client change' and 'signaling a need to alter the treatment plan if necessary' (Hatfield & Ogles, 2004).

Developing norms for self-report measures

In order for such measures to be useful, they need to meet a set of requirements. Measurements must be 'reliable and valid, and have good norms' (PsychPage, 2015). 'Norms', or normative values, allow a score on a psychometric test to be compared with the score expected from a certain group or population. Norms can show a percentile rank distribution, determining an individual's place within a population; or they can equate test scores to age or a level or grade (Anghoff, 1984, p. 39). Norms can be calculated for subgroups of a population to provide more precise measures of what is expected of a certain group. For example, subgroup norms for weight can allow an individual's weight to be compared with others of the same age and gender, which could be more meaningful than comparing weight to a wider population. An individual's test scores can be interpreted using norms to provide a clinical statement, for example, that a person is three kilograms underweight for their age, gender and height; or a child is a year ahead of their peers in reading age.

Anghoff (1984) outlines a number of statements on the construction of norms, particularly noting that 'The test must represent a reasonable operational definition of the characteristic under consideration' (pp. 40-41). This links the development of norms to the need for good construct validity within the test: the test must reliably measure a valid concept. Additionally, the point that 'The group (or groups) on which descriptive statistics are based should be appropriate to the test and to the purpose for which the test was designed and intended' emphasizes the need for attention to the sampling strategies used in studies included in forming norms. The context in which participants undergo testing in the development of norms must also be consistent with the context of testing for individuals whose scores are being compared against the norms (Psytech International, 2016, p.8). This helps to lessen bias arising from the testing methods. The list below provides Anghoff's (1984) full restatements of generalisations made by Conrad (1950) and Shrader (1960) on the construction of norms (pp. 40-41); Anghoff's addition is shown in square brackets.

1. The characteristic measured by the test must permit the ordering of individuals along a transitive asymmetric continuum from low to high; i.e., the scale must

be ordinal, at least.

2. The test must represent a reasonable operational definition of the characteristic under consideration, so that all tests that are intended to measure that characteristic will yield similar orderings of the same individuals.
3. The test must provide an evaluation of the same psychological characteristic throughout its range of scores.
4. The group (or groups) on which descriptive statistics are based should be appropriate to the test and to the purpose for which the test was designed and intended. This is a matter that will bear particular emphasis, since a norms population is meaningful and therefore useful *only* to the extent that it has been defined carefully. In some instances, as in the case of achievement tests in specific subject areas which are not uniformly offered or taught in precisely the same way, the problem of defining the norms population is not easy. A population must be chosen for which not only the subject of the test but the test itself is appropriate; and *appropriateness* is itself a concept that is frequently hard to define and keep distinct from the concept of *difficulty*.
5. Finally, data should be made available for as many distinct norm populations as there are populations with which it is useful for an individual or group to be compared.
6. [One might add to these a sixth point, namely that items for the test itself should have been selected on the basis of data for samples drawn from the population for which the test is intended – that is, the group or groups for which norms will be given.]

Considerations necessary during the development of norms include the fact that populations and samples are not always mutually exclusive. For example, owing to differing classifications of pain, an individual could fall into several populations such as those of chronic pain and of fibromyalgia. Furthermore, norms can be biased by errors of measurement in the testing process and by inaccuracies in the sampling strategy (Anghoff, 1984, p.63). The development of accurate norms therefore relies on attempts to minimise these sources of error.

Introduction to construct validity

In clinical psychology, measurements of symptoms and psychological experiences are often developed in an ad hoc way, in that there is no programme of research underpinning the construct validity and norms for the measures (Morley, in press, p18). Construct validity describes the extent to which a test measures what it is designed to measure. An example in psychology is whether a depression questionnaire is actually measuring the state commonly described as depression. In the history of science, the need for construct validity developed alongside changing approaches to scientific theory. From the late 19th century onwards, a position of *justificationism* supported the view that a theory can be fully proven or disproven based on empirical evidence. In the last century, this position shifted to a position of *non-justificationism*: a state of uncertainty in which a theory is never fully proven or disproven, but a closer approximation to the truth may be reached (Strauss & Smith, 2009, p.7; also see Popper, 1982). Theories of validity accordingly shifted from a focus on empirical validity, tested through the use of outcome measure items that predicted a specific criterion, to advances in knowledge that lead to the development of theories, and therefore a need for construct validity in order to assess the theories themselves.

Measuring construct validity

Cronbach and Meehl state that 'in order to provide evidence that a measure has construct validity, a nomological network has to be developed for its measure' (1955). Trochim (2006) clarifies that the nomological network is a philosophical foundation for testing constructs, rather than a useable methodology. In the nomological network, a construct is defined by measuring its relation to other constructs and behaviours. As an example from commonly accepted scientific understanding, the construct of phrenology has been removed from the nomological net of intelligence because of a lack of evidence for it. In contrast, the theory of brain mass evolution has been added to the nomological net of intelligence as evidence for it has grown.

Methods have been developed to establish the construct validity of individual outcome measures. In 1959, Campbell and Fiske developed the multi-trait multi-method (MTMM) meta-analysis model using the correlations of traits and methods to determine the extent of the convergent (correspondence between similar constructs) and

discriminate or divergent (dissimilarity of dissimilar constructs) validity. An example of its use would be three different concepts measured by three methods (e.g. a paper and pencil test, a direct observation, and a performance measure), with each concept measured by each method (Trochim, 2006). Ideally, the MTMM requires a fully-crossed measurement design in order to measure all traits using all methods, although Trochim (2006) states that it is possible to use only a multitrait matrix when multiple methods are not available. A limitation of the MTMM is that the interpretation of findings can be subjective in that there is no overall reliability coefficient.

Alternative strategies of measuring construct validity include a pattern matching approach, or a correlated uniqueness model. Pattern matching was put forward by Trochim (2006) as a way to 'estimate the degree to which the operational measures reflect our theoretical expectations'; i.e. it is a measure of construct validity regarding how well the observed measures are matched to the hypothesized measures. The pattern matching technique requires a concept map and 'specific theoretical pattern' (Trochim, 2006). As another example of a method of measuring construct validity, the correlated uniqueness model was proposed by Marsh (1989) as a way of determining method bias by 'allowing the error terms of variables measured by the same method to be correlated' (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003).

Construct validity in clinical psychology

In clinical psychology, assessing the validity of constructs may be particularly important given the vast overlap of symptoms between different diagnoses, and the different symptom patterns that can lead to the diagnosis of the same disorder. For example, four symptoms overlapping in the DSM-IV-R criteria for generalized anxiety disorder (GAD) and major depressive disorder (MDD) (restlessness; fatigue; difficulty concentrating; disturbed sleep) may contribute to high levels of comorbidity between the two diagnoses (Zbozinek et al., 2012). This can bring into question the usefulness of diagnosis when disorders are not unique constructs: wider discussion of this issue is beyond the scope of this thesis. Construct validity can help to determine which concepts are supported by psychological theory, and also examine overlap between concepts. The need for validation of constructs underlying self-report measures in clinical psychology can be applied to concepts of pain and pain-related experiences including

catastrophising. It is necessary to develop an understanding of the psychological impact of pain in order to begin to assess related concepts such as catastrophising. Construct validity is particularly relevant to addressing a criticism that the field of psychology has experienced an 'additive' approach of an ever-increasing list of psychological concepts, with little validation of the concepts or consideration of which concepts might have become obsolete (see McCracken & Morley, 2014, p.8 for a description of an additive process that has occurred for the cognitive model).

Measuring pain catastrophising: background concepts and previous research

Having considered historic and current understandings of the concept of pain, and ways in which constructs are measured and validated in clinical psychology, the third part of this chapter introduces the concept of pain catastrophising. A range of theories regarding the causes of pain catastrophising and its relation to other pain-related cognitions are explored.

The concept of pain catastrophising

In Beck's terminology, the concept of catastrophising as a cognitive error can be described as 'an irrationally negative forecast of future events' (reported in Quartana et al., 2009, p.745). A more specific concept of pain catastrophising takes the same definition but applies it to the forecast of future pain and a person's inability to cope with the pain. It has been suggested that worry is a motivational factor for trying to stop the cause of pain, but can evolve in the long term into catastrophising (Mathews, 1990). There are a number of hypotheses about how functional worry might evolve into dysfunctional catastrophising. Various perspectives are discussed below with reference specifically to pain catastrophising.

Pain catastrophising as cognitive error

In the 1970s, Aaron Beck and his colleagues made associations between pain and depression by identifying the cognitive errors involved in patients' evaluation of pain. Such errors included catastrophising (expecting the worst possible outcome), selective

abstraction (focusing on negative aspects), overgeneralization (assuming one negative consequence will apply to many events), and personalisation (placing blame for negative consequences on oneself) (Moss-Morris & Petrie, 1997, p.294). Pain catastrophising can conform to Beck's cognitive view of depression, with negative thinking applied to self (inability to cope with pain), the world (nothing can stop the pain) and the future (the pain will get worse).

Catastrophising as an emotional response

In clinical psychology, the experience of pain has been linked to emotional responses such as anger, hopelessness, sadness and anxiety (American Psychological Association [APA], 2015). Catastrophising may therefore be one part of an overall emotional response to pain. This in itself suggests an overlap in the concepts used in pain perception, as hopelessness is one of the three factors measured in the Pain Catastrophising Scale, and is also listed separately as an emotional response to pain.

Catastrophising as attention

The experience of pain has been linked to interruptions of cognitive activity in order for more attention to be given to the cause of the pain, presumably to seek a way of stopping the cause of pain (Crombez, Eccleston, Baeyens, & Eelen, 1998). In catastrophising, this is demonstrated by catastrophisers (people who catastrophise) showing more difficulty controlling or suppressing pain-related thoughts than non-catastrophisers (Sullivan, Rouse, Bishop, & Johnston, 1997). Catastrophising may therefore contribute to a survival-related function of attention to pain. The role of pain catastrophising in disrupting activities has been shown to be distinct from that of other pain-related concepts including anxiety sensitivity and injury/illness sensitivity (Vancleef & Peters, 2006).

Catastrophising as a psychosocial event

Authors have pointed to a function of catastrophising as eliciting care and empathy from others (Sullivan et al., 2001), regardless of the fact that this can draw more attention to the pain and increase the intensity of the pain experience. Catastrophising may therefore

be viewed as having a maladaptive psychosocial function of eliciting help and support from others.

Catastrophising as a coping strategy

Pain catastrophising is a subscale of the Coping Strategies Questionnaire. It has been theorised that catastrophising as a coping strategy may be closely linked with catastrophising as a social event (see above): with the role of catastrophising being to elicit help from others in order to increase the ability to cope (Sullivan, Tripp, & Santor, 2000).

Catastrophising as mis-directed problem solving

The links between worry and catastrophising are seen in a mis-directed problem solving model. The model suggests that catastrophic worry about pain can be aggrevated by an individual's fruitless attempts to gain medical resolution of the pain in cases in which medical resolution is not available or possible (Eccleston & Crombez, 2007). Flink, Boersma, MacDonald, and Linton (2012) used multiple regression of self-report questionnaires to confirm catastrophising as a 'mediator of the relation between biomedical problem framing and medically oriented problem-solving behaviour' (p.408). A fear-anxiety avoidance model has been used to explain how catastrophising influences participants' tendencies to engage in avoidance or defence behaviour that reinforces pain beliefs and heightens their perception of pain (Kachur, Carleton, & Asmundon, 2007).

Catastrophising as a neurological event

A number of studies have demonstrated links between the experience of catastrophising and specific changes to brain activity. Some studies have linked the brain activity to that expected during a state of anticipation (increased activity in the medial frontal cortex); to attention to pain (dorsal anterior cortex and dorsolateral prefrontal cortex) and other emotional aspects of pain (rostral anterior cingulate cortex, insul, and claustrum) (reported in Kjøgx, Kasch, Zachariae, Svensson, Jensen, & Vase, 2016; original studies by Gracely, Geisser, Giesecke, Grant, Petzke, Williams, & Clauw, 2004; and Seminowicz & Davis, 2006). The commonality in brain area activities between

catastrophising and other pain-related concepts could indicate an overlap of concepts, or similarities in the neural processing of pain-related experiences. A distinction has, however, been demonstrated between neural activity associated with pain and that associated with anticipation of pain (Ploghaus et al., 1999). This implies that pain-related concepts such as pain catastrophising might provide a clinical target for intervention distinct from the experience of pain.

The above descriptions already demonstrate a number of potential overlapping concepts within the construct of catastrophising. The concept of catastrophising itself may also overlap with other concepts such as fear of pain and depression. This reinforces the need for more research into the construct validity of catastrophising to determine its uniqueness as a concept and its relationship with other constructs.

The causal role of catastrophising in the experience of pain

The role of catastrophising in the wider experience of pain has been tested experimentally. It has been posited that catastrophising may play a causal role in pain experience, in that it can cause pain to be experienced more intensely. The theory suggests that the process of catastrophising enhances 'attention to painful stimuli' and results in 'heightened emotional responses to pain' (Gracely et al., 2004). This has been demonstrated experimentally, for example, with students asked to ignore pain in order to complete an attention-demanding audio discrimination task, with findings that participants with higher pain catastrophising scores showed greater task interference when expecting a painful experience as well as on being told that the painful experience was occurring (Crombez et al., 1998). The implication that pain catastrophising results in a decreased ability to attend away from threatening somatic information – or an increased vigilance for such information – has been replicated in studies demonstrating the detection of painful electrical stimuli predicted by pain-related fear and pain vigilance (Peters, Vlaeyen, & van Drunen, 2000); and impaired ability in catastrophisers to use a distraction coping strategy such as imagery when experiencing pain (Heyneman, Fremouw, Gano, Kirkland, & Heiden, 1990). The latter study categorized participants as 'catastrophisers' or 'non-catastrophisers' based on their reporting of 'fearful or negative thoughts or images' during a trial. This calls into question the

concept of catastrophising used, and the extent to which it overlaps with broader concepts of negative affect and cognition.

The above studies suggest that people categorized as ‘catastrophisers’ have increased fear of pain, resulting in increased attention to pain-related stimuli. Further studies suggest that people who catastrophise score higher on quantitative pain rating scales and qualitatively report more intensely painful experiences (e.g. Geisser, Robinson, Keefe, & Weiner, 1994). In 1978, Chaves and Brown asked dental patients to report their thoughts and images and the strategies they used to deal with these during a stressful dental procedure. Their finding was that those who had catastrophic thoughts were more likely to experience high levels of distress (reported in Sullivan, 2009, p.3). A further experiment in 1979 used a cold pressor procedure (immersing an arm in cold water to induce pain) with students. Findings from interviews after this procedure were that participants who reported catastrophic thinking (in this case, thought content reflecting fear, worry, and the inability to divert their attention away from pain) also reported the highest levels of pain experienced (cited in Sullivan, 2009, p.4). Such experiments demonstrate a correlation between catastrophising and the pain experience. However, difficulties in measuring levels of pain raise questions regarding the direction of causation: it is also possible that catastrophising itself is caused by more intense pain experiences.

An experimental study by Kjøgx et al. (2016) demonstrated a causal effect of catastrophising on pain perception. The authors manipulated participants’ pain catastrophising levels using hypnotic suggestion, before measuring self-reports of pain perception. The experiment was carried out with participants with chronic headache, and with healthy participants who had pain experimentally induced. The authors found that hypnotic suggestion could both significantly increase and decrease reports of pain intensity and pain unpleasantness in patients and healthy volunteers. This implies the existence of a causal link between the concepts of pain catastrophising and pain perception.

As well as predictions of pain intensity explained above, other clinical variables related to prognosis and recovery have been tested. Keefe, Lefebvre, Egert, Affleck, Sullivan,

and Caldwell (2000) found pain catastrophising to be correlated with higher levels of disability in people with osteoarthritis knee pain. Disability was again predicted by the level of catastrophising in participants with chronic low back pain by Kovacs et al. (2011). A negative correlation between pain catastrophising and endurance and strength was found in people with chronic low back pain by Larivière, Bilodeau, Forget, Vadeboncoeur, and Mecheri (2010). These findings suggest a role of pain catastrophising in predicting other pain-related clinical outcomes. Further evidence from a range of studies across participant groups would help to further establish the predictive relationship between pain catastrophising and other constructs.

Demographic differences in pain catastrophising

There is some evidence to suggest that different groups of people, as well as different individuals, catastrophise about pain to different extents. Studies have been conducted to establish difference in pain catastrophising between genders, people of different ages, people from different cultural backgrounds or who speak different languages, and people with different pain diagnoses.

Gender differences

In studies in which healthy participants complete a cold pressor task, Sullivan consistently reported women as catastrophising about pain more than men (Sullivan, Bishop, & Pivik, 1995; Sullivan, Tripp, & Santor, 2000; Sullivan, Tripp, Rogers, & Stanish, 2000; replicated by Forsythe, Thorn, Day, & Shelby, 2011). There was a significant gender difference in the same direction in a cross-sectional study of participants with osteoarthritis of the knee using the pain catastrophising scale of the Coping Strategies Questionnaire (Keefe et al., 2000). This suggests that women catastrophise about pain more than men. However, in a clinical sample of participants with acute whiplash, Rivest, Côté, Dumas, Sterling, and De Serres (2010) found no gender differences in catastrophising for cold pain and pressure pain tasks. Factor analysis conducted on the Pain Catastrophising Scale indicates that women score higher than men on PCS total scores and subscale scores for rumination and helplessness (Osman et al., 1997; 2000). In summary, evidence generally but not always points to

higher levels of pain catastrophising in women than in men, but the evidence is not consistent across healthy and clinical samples.

Age differences

Keefe and Williams (1990) found no significant age differences in scores on the pain catastrophising subscale of the Coping Strategies Questionnaire by participants with chronic pain. Other studies, however, have shown age differences. Lower catastrophising scores were found for older participants in a dental setting (Sullivan & Neish, 1998) and in older women after breast cancer surgery (Jacobsen & Butler, 1996). In contrast, older school students have been found to have higher catastrophising scores (Bédard, Reid, McGrath, & Chambers, 1997). Sullivan et al. (1995) explained the discrepancy in scores by speculating that 'age differences in young adolescents might not be comparable to age differences in adults' (p.524). The different settings and contexts of the studies, for example, the recruitment of healthy students versus participants with pain and other health conditions, suggest a number of other possible reasons for the discrepant findings for the effect of age on pain catastrophising.

Language differences

Several studies have been carried out to establish the validity of foreign language versions of the PCS (examples include the analysis of the Italian version conducted by Monticone et al., 2012; and of the German version by Meyer, Sprott, & Mannion, 2008). However, there have been no studies into the difference in pain catastrophising scores of participants using different language versions of the PCS or other measures of pain catastrophising.

Cultural differences

Cultural or racial differences have been cited in pain catastrophising scores for participants using the same language version of the PCS. Studies recruiting healthy undergraduate participants reported higher levels of pain catastrophising in Chinese Canadians compared to European Canadians (Hsieh, Tripp, Ji, & Sullivan, 2010) and in African-Americans compared to white-Americans (Forsythe et al., 2011). Therefore

some limited evidence from healthy participants suggests the presence of cultural factors in mediating pain catastrophising scores.

Pain diagnosis differences

Although a number of studies have reported pain catastrophising scores for participants with different pain diagnoses, no review or commentary has yet consolidated and compared the potential differences in scores between these pain groups.

The above studies indicate that individual studies have been carried out on a limited range of participant groups which suggest some demographic differences in pain catastrophising using the PCS and the pain catastrophising subscale of the Coping Strategies Questionnaire. As yet, no comprehensive investigation of demographic differences in pain catastrophising between participant groups has been conducted.

Pain catastrophising in psychological clinical practice

It was established above (see section 'Catastrophising as a neurological event') that pain catastrophising may be treated in its own right, separately from the experience of pain. Of significance for clinical practice, studies have found that reductions in catastrophising following cognitive-behavioural interventions can result in better adjustment to chronic pain including higher levels of activity and lower levels of emotional distress (Turner & Clancy, 1986; Parker et al., 1989; Vienneau, Clark, Lynch, & Sullivan, 1999; all in Sullivan et al., 2001). This suggests a potential direction for clinical psychology in pain: reducing catastrophising may have other positive psychological effects.

Measuring pain catastrophising: Validity and reliability of the PCS

The paragraphs above outlined theoretical perspectives on pain catastrophising. The next part of this chapter moves on to introduce the development of measurement tools including the Pain Catastrophising Scale. Established strengths and limitations of the scale are highlighted, along with an introduction to the meta-analytic theories and methods that can be used to further clarify psychometric properties of scales.

A background to measuring pain catastrophising

A number of self-report questionnaires have been used to measure pain catastrophising and other pain-related cognitions. This section outlines the measures and their history.

Following the studies cited above that demonstrate a correlation between catastrophising and the intensity of the pain experience (see section 'The causal role of catastrophising in the experience of pain'), Lefebrve developed the Cognitive Errors Questionnaire (CEQ) in 1981. The CEQ was 'designed to measure general cognitive distortion as well as four empirically derived dysphoric cognitive errors (catastrophising, overgeneralisation, personalisation, and selective abstraction)' (Lefebrve, 1981, p.517). The CEQ uses two subscales to distinguish between cognitive distortions associated with life events (e.g. experience of depression) and with chronic pain.

In 1983, the Coping Strategies Questionnaire (CSQ) was developed by Rosenstiel and Keefe. The CSQ contains a catastrophising subscale (CAT) designed to reflect elements of helplessness and pessimism in relation to the individual's ability to deal with their experience of pain. Higher scores on the CAT subscale of the CSQ correlate with higher levels of physical and emotional distress associated with the individual's pain (Sullivan, 2009, p.4). Benefits of the CAT are that it has 'good psychometric properties, is short to administer, and has been consistently associated with depression, intensity of symptoms, and disability in chronic pain' (Moss-Morris & Petrie 1997, p. 294). However, the association between the CAT and depression has raised questions regarding a potential confound between its measurement of catastrophising of chronic pain and of depression. Sullivan and D'Eon (1990) highlighted that CAT items such as "I feel my life isn't worth living" could reflect depressive cognitive errors rather than pain-specific catastrophising, and demonstrated that the correlation between the CAT and outcomes in chronic pain treatment were not significant when controlled for depression.

Sullivan et al. created the Pain Catastrophising Scale (PCS) in 1995 'in an effort to develop a comprehensive evaluation instrument that would encompass the different

perspectives on catastrophising that had been discussed by previous investigators' (Sullivan, 2009, p.4).

Existing evidence base for and strengths of the PCS

The PCS aims to focus solely on measuring pain catastrophising (see Appendix A for the PCS questionnaire). The PCS is widely used in clinical psychology as the 'reference standard psychometric tool for pain catastrophising' (Leung, 2012). During the development of the PCS, Sullivan et al. investigated the factor structure in a sample of 439 students (1995). The authors used principal components analysis to determine that the PCS measures a single concept of catastrophising which is characterized by three related dimensions of rumination, helplessness, and magnification. Confirmatory factor analysis has since been used in English and Dutch versions of the PCS to confirm this factor structure in samples of students (Osman et al., 1997); community and pain outpatient samples (Osman et al., 2000); and pain-free students, chronic low back pain patients, and fibromyalgia patients (van Damme, Crombez, Bijttebier, Goubert, & Houdenhove, 2002). Overall, these studies suggest consistency of the 3-factor model of pain catastrophising across participant groups in English and Dutch versions of the questionnaire.

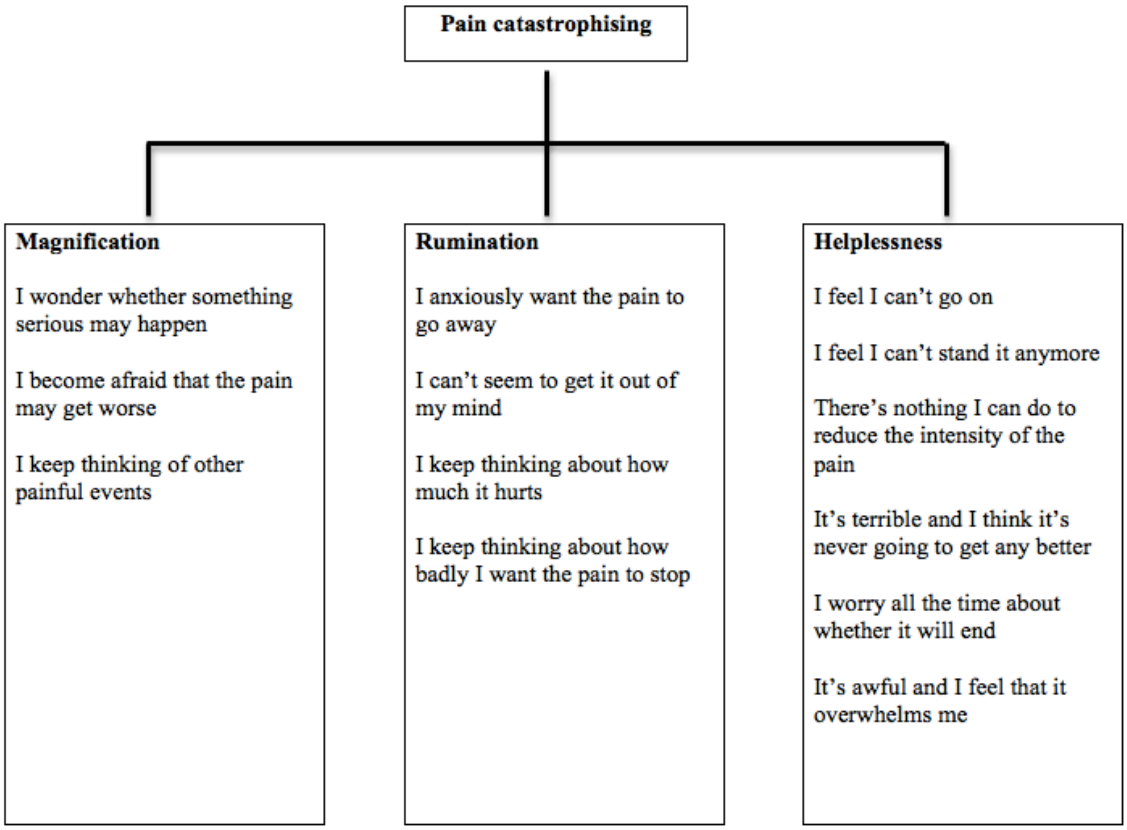

Figure 1. Hierarchical factor structure of pain catastrophising and corresponding Pain Catastrophising Scale items. Image adapted from Quartana, Campbell, & Edwards, 2009

Questions remain regarding the relationship of catastrophising to other constructs that influence pain perception. The uniqueness of the concept of catastrophising has been questioned, with suggestions that catastrophising could be one aspect of a more general negative affect or part of the related concept of fear of pain. A number of studies have suggested that pain catastrophising shares 'significant variance with broader negative affect constructs, such as depression, anxiety, anxiety sensitivity, worry and neuroticism' (for example pain catastrophising was not differentiated from negative mood when using the catastrophising subscale of the CSQ in a 2005 study by Hirsh, Riley and Robinson, cited in Quartana et al., 2009). A study of the CSQ using regression analysis and controlling for negative mood has suggested that catastrophising 'contributed minimally to the prediction of pain' (Hirsh, George, Riley, & Robinson, 2007, p.75). The finding points to a potential construct redundancy of catastrophising. This contradicts Keefe's finding that catastrophising can predict later depression

'beyond the variance accounted for by initial depression' (reported in Sullivan et al., 2001). The contradiction may warrant further investigation to determine the place of catastrophising in pain perception, and the construct validity of measures of catastrophising used in clinical psychology.

Osman et al. (2000) specifically found that PCS scores correlated highly with ratings of pain severity and interference, which could indicate an overlap with these constructs. Research using regression analyses on data from a sample of people with chronic pain has already demonstrated a high degree of construct redundancy of pain catastrophising as measured by the catastrophising subscale of the Coping Strategies Questionnaire (Hirsh, George, Riley, & Robinson, 2007). This study specifically found that measures of depression, anxiety and anger accounted for a large proportion of the variance found in the measurement of pain catastrophising. Mounce, Keogh and Eccleston also found pain catastrophising to be highly related to measures of mood in a sample of pain-free participants (2010). Dixon, Thorn and Ward (2004) refer to confounding of variables in the measurement of catastrophising using the PCS and other measures of pain-related catastrophising. The authors describe distinct concepts of pain catastrophising, pain intensity, and pain unpleasantness; however, they state that the assessment of pain catastrophising uses words that reflect pain unpleasantness such as 'terrible' and 'awful'. For this reason, '[a]greement with PCS statements can be expected to increase with increasing pain severity' (p. 195). The direction of causation in the relationship between pain catastrophising and other constructs such as low mood has not been established.

However, difficulties in attempts to define a unified concept of pain processing have led to conclusions that it is appropriate to investigate individual concepts such as pain catastrophising in their own right. Dittmar, Krehl and Lautenbacher (2011) used a multi-method model to study associations between participants' responses on the PCS as well as two other self-report measures (Pain Anxiety Symptoms Scale and Pain Hypervigilance and Awareness Scale) and implicit measures of pain related information processing (the dot-probe task for pain words and a word-processing task for pain words allowing event-related brain potential recordings). The authors did not find evidence of convergent and divergent validity between the measures, suggesting that a unified

construct of pain processing that includes pain catastrophising alongside other concepts is not valid. Therefore, although a number of studies and theories have suggested that the concept of pain catastrophising may not be entirely distinct from other pain concepts, it also cannot be treated as part of a unified concept of pain experience. Further research into pain catastrophising as a single construct is therefore indicated. Further evaluation of the uniqueness of the concept of catastrophising could help to establish the extent to which the PCS is useful and accurate in measuring pain-related cognitions.

Established strengths and limitations of the PCS

A number of limitations of the PCS have been highlighted above regarding its correspondence with other pain-related concepts and the uniqueness of catastrophising as a concept. The concept of catastrophising as used in the PCS has been questioned in relation to other pain-related concepts: for example, the distinction between trait pain (an 'enduring personality construct' that affects how a person will respond to painful experiences (Wade, Riddle, & Thacker, 2012)) and state pain (pain experiences that demonstrate 'within-person variation across time' (Sturgeon & Zautra, 2013) and are influenced by the context of the pain). It has been argued that state and trait pain are not distinguished in the PCS (Quartana et al., 2009), leading to questions regarding the relevance of the PCS to the understanding of pain-related cognitions.

However, the PCS does benefit from research supporting its reliability and predictive validity: for example, Osman et al. (1997) conclude the PCS has 'strong potential' based on tests of its factor structure, reliability and validity.

The PCS is subject to limitations common to many retrospective self-report measurements of cognitions. The necessity for retrospective report creates the potential for recall bias and inaccuracy, along with 'an inability to determine sequential relations between variables' (Turner, Mancl, & Aaron, 2004, p.103). In the case of catastrophising, the method of measurement does not provide insight into the process of catastrophising or the direction of causation (i.e. does catastrophising cause pain or does pain cause catastrophising?). A study using daily computerised interviews to record the rumination subscale of the PCS found this measure of catastrophising to be stable

within participants over time (Turner et al., 2004 p.108); but participant reports were still retrospective in that they were asked to record their experiences over the past three hours. The retrospective nature of self-report of cognitions has to be accepted as a necessary characteristic of the attempt to gain insight into another person's thought processes.

Suggestions have been made for improvements to the PCS, such as the additional measurements of a 'worst case scenario' construct including the items "I might become totally disabled" and "I might end up losing my job and not able to support my family" (Turner & Aaron, 2001). However, adding questionnaire items would invalidate the findings from investigations into the factor structure of the PCS (Osman et al., 1997; 2000; van Damme et al., 2002; see 'Existing evidence base for the PCS' above).

The currently established norms for the PCS describe a clinical cut-off score of 30 based on correspondence to the 75th percentile of PCS scores in a clinical sample of chronic pain patients with occupational injuries in Nova Scotia (Sullivan et al., 1995). Norms for specific sub-groups of clinical and non-clinical samples would provide a more accurate way of interpreting an individual's PCS scores. Broader samples of participants from different backgrounds and countries would also make the norms more widely generalizable. In terms of psychometric properties, Pedler reported in a commentary review that 'there are currently little data available regarding the test-retest reliability, sensitivity to change, and clinically meaningful change of the PCS' and that '[f]urther research investigating these dimensions of the PCS would significantly increase the clinical utility of this tool' (2010, p.137).

Meta-analysis and theory of data

In psychometric meta-analysis, data from multiple studies is collected systematically in order to determine statistical properties of a measurement scale. Aims of individual meta-analysis are influenced by the theory of data used. Meta-analysis can be used to 'summarise and describe in a general way the studies in a research literature' (Hunter & Schmidt, 2004, p.512, referring to meta-analytic methods set out by Glass, 1976). A contrasting method of meta-analysis aims to 'correct for the distorting effects of sampling error, measurement error, and other artifacts that produce the illusion of

conflicting findings [in small-sample studies]' (Hunter & Schmidt, 2004, p.17). Artifacts of research studies include sampling error, measurement error, biased sampling, data errors, and 'other causal factors that distort raw data in research studies' (p. 511). Correcting for artifacts in this way can allow the researcher to estimate results as they 'would be obtained in an infinitely large, perfectly designed study or sequence of such studies' (Rubin, 1990, p.157).

Aims of this thesis

This thesis aims to explore psychometric properties of the PCS using a systematic search strategy and meta-analysis, as follows:

1. Evidence will be drawn from multiple studies to provide more accurate data on test-retest reliability and internal reliability of the scale. This meta-analysis will aim to establish characteristics of the PCS using Hunter and Schmidt's (2004) approach of correcting for artifacts.
2. PCS scores from multiple studies will be combined to assess the sensitivity of the scale to demographic and diagnostic factors including sex, language, age, and type of pain. This will help to establish whether PCS scores are stable across participant groups.
3. PCS scores from multiple studies will allow the creation of norms for more specific populations, particularly people with different pain diagnoses. This will help clinicians to make more accurate interpretations of service users' scores.
4. The thesis aims to assess construct validity through analysis of correlations between the PCS and measures of other constructs. This will allow further exploration of the relationship between pain catastrophising as measured by the PCS and other pain-related constructs.

Chapter 2: Methods

The methods used in this thesis followed the guidance for systematic reviews set out by the PRISMA group (Moher, Liberati, Tetzlaff, & Altman, 2009). This chapter outlines the methods used to collect and prepare data, followed by the meta-analytic methods used to meet the aims of the thesis.

Protocol and registration

The research protocol for the review and meta-analysis is registered on PROSPERO (prospective register of systematic reviews) at the University of York's Centre for Reviews and Dissemination (CRD). The registration number is CRD42016032863. The intended purpose of registering the review is to increase transparency of the aims and methods of the research, and to help avoid duplication by publishing the aims in the public domain.

Eligibility criteria

In order to carry out screening of the studies found through the database searches, eligibility criteria were set to determine which studies were to be included in the review and meta-analysis. The eligibility criteria are outlined below.

Study eligibility criteria: Studies using the PCS were included in the meta-analysis. Participants aged 18 and over, and with any health condition or none, were included. Primary studies of randomised and non-randomised designs were considered, with all intervention types that involved two or more participants considered. Secondary analysis of data was considered provided that the data did not duplicate that of another included study. PCS scores must be included as a self-report measure in included studies. Studies using the spouse-completed PCS and not the self-report PCS were excluded.

Report eligibility criteria: Included studies report the mean PCS score, standard deviation of PCS scores, and number of participants for at least one participant group,

and report demographic information including age and sex of participants and clinical details of the sample such as diagnostic label. Studies published in 1995 and onwards were included; those published pre-1995 were excluded because the PCS was published in 1995. Studies in languages other than English were excluded. Peer reviewed, published studies were included.

A table of inclusion and exclusion criteria is presented below.

Table 1. Inclusion and exclusion criteria for studies screened for inclusion in the current review and meta-analysis.

	Include	**Exclude**
Participants	Aged 18+ years Any health condition or no health condition	Child (17 years and under)
Intervention	Any intervention or no intervention	
Outcomes/measures	Use of PCS	No use of PCS Use of spouse-completed PCS only Use of modified PCS only (some items excluded; short version)
Study design	Randomised or non-randomised trial; quasi-experimental trial	Systematic review, meta-analysis, editorial or other non-primary study; case study

Study report	Reports demographic information (e.g. age and sex) and clinical information (e.g. diagnostic label) of participant group(s)	Does not report demographic information and clinical information of participant group(s)
	Reports psychometric data (mean, standard deviation, sample size) for PCS scores	Does not report psychometric data for PCS scores

Information sources

Studies for potential inclusion in the review and meta-analysis were identified by searching electronic databases. The search strategy was adapted for Cochrane Library, Cinahl, Embase, PsycInfo, PubMed, and Web of Science (all 1995-present). The last search was run on 30 November 2015.

Search strategy

The following search terms were used to search electronic databases: pain catastrophi* scale*, pain catastrophi* measure*, pain catastrophi* questionnaire*. Truncation wildcard characters (* or equivalent, depending on the database) were used to maximise the search results by retrieving alternative spellings or search terms, e.g. ‘catastrophising’, ‘catastrophizing’, ‘catastrophisation’, ‘catastrophization’ and similar terms. Proximity searches were used to find papers containing the words ‘pain’ and variations on the word ‘catastrophising’ within 3 words’ proximity. An example search strategy is included in Figure 2. The search strategy was not peer reviewed, but was reviewed by a university librarian, whose advice was followed in order to create a more

comprehensive search that was more likely to find all papers relevant to the review and meta-analysis.

1. pain catastrophi* scale*
2. pain catastrophi* measure*
3. pain catastrophi* questionnaire*
4. catastrophization [MeSH terms]
5. pain measurement [MeSH terms]
6. pain NEAR/3 catastrophi*
7. #4 AND #5
8. #1 OR #2 OR #3 OR #6 OR #7

Figure 2. Search strategy used to identify potentially relevant studies from the Cochrane Library

Requests were sent to authors for data missing from otherwise relevant studies. 81 requests were sent for PCS scores, and 21 requests were sent for demographic data.

Of the 81 requests sent by email to authors for PCS scores that were missing from papers, the replies were eight responses with scores; four responses explaining that the data was not available; 14 invalid email address responses; two late responses; and no response from 53 authors.

Of the 21 requests sent by email to authors for missing demographic data, the replies were one response explaining the data was not available; seven invalid email address responses; and no response from 13 authors.

Study selection

One reviewer (CW) screened the title and abstract of the studies retrieved in the database searches. A random sample of 5% of the papers were screened by title and abstract by a second reviewer (SM) and the inter-rater reliability of screening was calculated. The papers for second screening were selected using a random number sequence generator randomnumber.org, which uses atmospheric noise to select the sequence. The first 186 papers (5% of the total number of papers) in the sequence were selected for the second reviewer to code. Another ten papers were selected randomly using the same method, and used as a training package for the second reviewer, along

with descriptions of the inclusion and exclusion criteria for papers. Discrepancies were discussed and resolved between the two reviewers.

Data collection process

A data collection form was created on SPSS and piloted to ensure the form captured the necessary data from different types of papers (e.g. randomised controlled trials and cohort studies). Two reviewers separately extracted data from a random sample of 10 papers. Data was entered directly into SPSS. Discrepancies were resolved through discussion between the reviewers, and amendments were made to the data extraction form as a result of the pilot process. The form was adjusted to allow for duplicate data items (for example, some studies included data for the whole sample as well as PCS scores from subgroups of the sample; the amended form allowed all data to be entered along with a column to declare whether the data was duplicated) and pooled data from studies that reported only PCS subscores or scores from subgroups but demographic data from the whole sample. Data was then extracted from all included studies and entered to the amended form.

In the full database, sample sizes across studies were juxtaposed with authors, treatment group, PCS mean scores, male/female participants, and age means and standard deviations to check for any double counting of data. All papers reporting the same study were reviewed for inconsistencies, and papers reporting more data (for example, reporting more correlations with other measures) were selected for use in the meta-analysis as long as no inconsistencies were present.

Data items

The following data was sought from studies during the data extraction process:

Sample characteristics

Diagnostic status

Age

Gender

Treatment
Language

Study data
Sample size
Mean PCS score
Standard deviation of PCS score
Internal reliability of PCS score (Cronbach's alpha)
Mean score, standard deviation, and internal reliability (Cronbach's alpha) of PCS subscales
Correlations between the PCS score and other measures, e.g. measures of fear of pain or of pain intensity

Details including the study type were recorded, and each study was given a unique identifier.

Study types
The definition of study types included in the current systematic review and meta-analysis were adapted from categories set out by the Georgia State University State Library (2016), with an additional study type in square brackets included for this thesis:

- **Randomized controlled trial**
  A controlled clinical trial that randomly (by chance) assigns participants to two or more groups.
- **Non-randomised controlled trial**
  A clinical trial that assigns participants to two or more groups without using a randomisation procedure
- **Cohort study (prospective observational study)**
  A clinical research study in which people who presently have a certain condition or receive a particular treatment are followed over time and compared with another group of people who are not affected by the condition.

- **Case-control study**
  Case-control studies begin with the outcomes and do not follow people over time. Researchers choose people with a particular result (the cases) and interview the groups or check their records to ascertain what different experiences they had. They compare the odds of having an experience with the outcome to the odds of having an experience without the outcome.
- **Cross-sectional study**
  The observation of a defined population at a single point in time or time interval. Exposure and outcome are determined simultaneously.
- **Case series**
  A report on a series of patients with an outcome of interest. No control group is involved
- **Other**
  Usually an experimental study with no control group
- [**Psychometric study**
  A study of the validity or reliability of an outcome/self-report measure]

The diagnostic category of participant groups was recorded according to classifications as presented by the International Association for the Study of Pain (2011). No samples in this meta-analysis reported participants with spinal and radicular pain syndromes, so this category was removed. The remaining classifications were as follows:

- Relatively generalized pain syndromes (referred to as 'generalised pain' for short)
  Examples of studies' descriptions of participant groups included in this category: Fibromyalgia; rheumatoid arthritis; diabetic neuropathy; spondyloarthritis; HIV-associated sensory polyneuropathy
- Relatively localized syndromes of the head and neck ('head and neck pain')
  Examples: Temperomandibular disorder; burning mouth syndrome; craniofascial disorder; chronic headache
- Spinal and radicular pain of the cervical and thoracic regions ('cervical and thoracic pain')
  Examples: Whiplash; whiplash-associated disorder

- Local syndromes of the upper limbs and relatively generalized syndromes of the upper and lower limbs ('upper or upper and lower limb pain')
  Examples: Upper extremity pain; shoulder/hand/wrist pain; pain following elbow injury; erythromelalgia; brachial plexus injury; neuropathic pain of upper or lower limbs; upper extremity pain condition
- Visceral and other syndromes of the trunk apart from spinal and radicular pain ('trunk pain')
  Examples: Dyspareunia; primary or secondary provoked vestibulodynia; pelvic pain; painful bladder syndrome
- Spinal and radicular pain syndromes of the lumbar, sacral, and coccygeal regions ('low back pain')
  Examples: Low back pain; lumbar spinal stenosis; degenerative spinal disease
- Local syndromes of the lower limbs ('lower limb pain')
  Examples: Knee or hip osteoarthritis; leg/knee/thigh/hip pain condition
- Healthy participants
- Other (including more generic diagnoses such as 'chronic pain', and mixed diagnoses such as 'asthma and generalized pain')

Risk of bias in individual studies

Risk of bias is defined as the risk of 'a systematic error or deviation from the truth, in results or inferences' (Higgins & Green, 2008). Assessment of risk of bias concerns the internal validity of studies included in a review, including 'the extent to which the design and conduct of a study are likely to have prevented bias' (Cochrane Collaboration, 2005).

The risk of bias of each included study was assessed using a component approach, as recommended in the PRISMA statement (Moher et al., 2009). The component approach assesses individual components of each paper, rather than using a checklist or scale to give an overall score. Relevant components from the Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies (National Heart, Lung and Blood Institute, 2014) were piloted for use in this review and meta-analysis. An aim of this review is to establish normative values for the PCS. Any biases relating to population

samples in included papers would therefore influence the reliability of the norms. This review concerns only baseline data and no outcome data or treatment effects. Therefore the risk of bias components related to sample strategy and description were relevant to this review. The components used to assess risk of bias in individual studies were as follows:

1. Was the study population clearly specified and defined?
2. Was the participation rate of eligible persons at least 50%?
3. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study pre-specified and applied uniformly to all participants?

All studies were treated as cohort and cross-sectional studies for the purpose of risk of bias screening, as methodology related to other study types such as randomisation processes, measurement of outcomes after the baseline period, and outcome effect sizes were not relevant to this review and meta-analysis.

The extent of risk of bias within individual studies was considered during the discussion of meta-analysis results of this study. Sensitivity analysis was carried out to ascertain the impact of bias on the overall effect sizes found in the meta-analysis, and was reported in the results section. Meta-analysis of effect size was conducted first for all studies, and then repeated only for studies known to be eligible according to risk of bias screening, following the Cochrane method of conducting systematic reviews (Higgins & Green, 2011).

Summary measures

Data extracted from included studies was aggregated to provide an overall effect size (mean PCS score). The primary effect size was participants' baseline scores on the total PCS questionnaire, with PCS subscale scores as secondary effect sizes. A random-effect model was used as it was not expected that included studies would have a common effect size. Instead, preliminary eyeballing of the pilot data suggested that studies included in the meta-analysis came 'from a population that is likely to have a different

effect size than any other study in the meta-analysis' (Field, 2001) as a result of various factors including differences in diagnostic status, age and gender of participants, and differences in PCS scores between PCS language versions and countries of study. Weights were computed for the PCS score mean, variance and reliability for each sample. Samples were groups of participants; depending on the study type, some studies included one sample while others included subgroups or comparison or control groups of participants.

The psychometric data was also aggregated in order to establish normative values for a general population and of population subgroups such as those with diagnoses of pain conditions within more specific categories. For each sub-population, weighted values for the mean and standard deviation of PCS scores were calculated using a random effects model and reported alongside demographic data on weighted age and standard deviation of age, gender distribution, and language of PCS questionnaire completed by the included participants.

Synthesis of results

Data handling

On completing the extraction of data from studies to a database, data preparation was completed following guidelines from an SPSS tutorial (van den Berg, 2013). The main steps involved conducting a case count and variable count; creating unique case identifier variables; checking and modifying undesirable variable types; specifying missing values and making decisions about how to treat cases with many missing values; identifying cases with inconvenient distributions of scores; and identifying variables with little or no data in order to make decisions about removing or merging variable categories.

Data checks were conducted to ensure the consistency and accuracy of data. For example, checks were carried out on the minimum and maximum PCS scores (scores cannot exceed 52; subscale scores must also be within the possible range of scores); and that there was no missing data for PCS scores and sample size for each sample.

Data pooled for subgroups

Some papers included in the meta-analysis reported PCS scores for subgroups of participants, but reported demographic details for the whole sample of participants; or reported demographic data for subgroups and PCS scores for the whole sample. For studies in which there was declared to be no significant difference between the PCS scores for the subgroups, and the group sizes were the same, the data was pooled for this meta-analysis so that there was full demographic data and PCS scores for the entire sample.

For studies in which there were significant differences between the PCS scores of subgroups of participants, or the difference was not reported, or the group sizes were unequal, then the PCS scores of the subgroups were included in the meta-analysis with missing demographic data.

Studies in which demographic data was provided for subgroups of participants but PCS scores were reported for the whole sample, and the authors declared that there was no significant difference in demographic considerations between the subgroups, and the group sizes were equal, the demographic data was pooled for this meta-analysis. For studies as above but in which there was a significant difference in demographics between subgroups, or there was no analysis of difference, or the group sizes were unequal, the PCS data was included for the whole sample but with missing demographic data.

When pooling occurred, data from subgroups was pooled as follows:

Subgroup means were pooled to construct a grand mean (Everitt & Skrondal, 2002) for the whole sample:

$$x_{GM} = \frac{\Sigma x}{N}$$

where N is the total number of sets, and $\sum x$ is the sum of the mean of all sets

Subgroup standard deviations were pooled using the formula below:

$$SD_{pooled} = \sqrt{\frac{(n_1 - 1)SD_1^2 + (n_2 - 1)SD_2^2 + \cdots + (n_k - 1)SD_k^2}{n_1 + n_2 + \cdots + n_k - k}}$$

where n_1, n_2, . . . n_k are the sample sizes (number of participants in the subgroup) at each level of the variable *x*, and SD_1^2, SD_2^2, . . ., SD_k^2 are their respective standard deviations. *k* is the number of groups included in the analysis.

Data pooled from PCS subscales

A number of studies included in this meta-analysis reported data for PCS subscales, but not for the total scale. Data was pooled to calculate the total scale mean and standard deviation. The subscale means were added to calculate the full scale mean. Standard deviations of the subscales were combined as follows to calculate the full scale standard deviation:

$$SD_{total\ scale} = \sqrt{SD_1^2 + SD_2^2 + SD_3^2}$$

where SD_1, SD_2, and SD_3 are the standard deviations of the PCS subscale scores (rumination, helplessness, and magnification)

Missing data

Papers that reported PCS scores but did not report demographic data were included in the data extraction database.

For papers in which the standard error of the mean was provided for PCS scores or demographic data, but no standard deviation was provided for those scores, the standard deviation was calculated using the equation below.

$$SD = SEM * \sqrt{n}$$

where *SEM* is the standard error of the mean and n is the sample size

For papers in which confidence intervals were reported for PCS scores but no standard deviation was given, the standard deviation was calculated using the equation below for sample sizes greater than or equal to 100.

$$SD = \sqrt{N}X\frac{(upper\ limit - lower\ limit)}{3.92}$$

where *upper limit* is the upper limit of the confidence interval, and *lower limit* is the lower limit of the confidence interval

The equation below was used to calculate the standard deviation from given confidence intervals for a sample size of less than or equal to 99.

$$SD = \sqrt{N}X\frac{(upper\ limit - lower\ limit)}{t}$$

where t is the t value of the 95% confidence interval for the sample size

The above calculations were carried out in accordance with guidelines provided in the Cochrane Handbook for Systematic Reviews of Intervention (Higgins & Green, 2011).

Risk of bias across studies

It was posited that there was unlikely to be a high risk of publication bias in the included data, given that PCS scores were not the primary outcome in all studies and the data extracted was baseline scores rather than outcome data. For these reasons, no risk of bias analysis across studies was undertaken.

Meta-analysis to explore the psychometric properties of the PCS

Calculating weighted means, standard deviations and reliability alphas of PCS scores

Weighted scores were computed for the PCS mean, standard deviation, and Cronbach's alpha for each sample in which these data were available. The weights used were based on the standard error for each sample, as follows:

mean: effect size of standard error:

$$se = \frac{sd}{\sqrt{n}}$$

weight (w_i):

$$w_i = \frac{1}{se^2}$$

standard deviation: effect size of variance (v_i):

$$v_i = \frac{2 * sd^4}{(n-1)}$$

weight of sd variance:

$$w_i = \frac{1}{v_i}$$

variance of Cronbach's alpha:

$$v_i = \frac{18 * j_i * (n_i - 1) * (1 - \alpha_i)^{2/3}}{(J_i - 1) * (9 * n_i - 11)^2}$$

where *j* is the number of items in the psychometric scale

weight of variance for alpha, as weight of variance for sd:

$$w_i = \frac{1}{v_i}$$

The weighted scores were used to compute the mean, standard deviation, reliability coefficient, confidence intervals, and random effects variance components for PCS scores across studies. The weighted scores were additionally used in subgroup analysis to compute normative values for populations with different pain-based diagnoses.

Reliability estimates

The internal consistency reliability for the PCS and its subscales was calculated by finding the weighted mean of the Cronbach's alpha statistics reported in studies using the PCS. The test-retest reliability for the total PCS scale was calculated using the weighted mean test-retest reliabilities reported in studies.

Subgroup analysis

Wilson's (2006) macros for SPSS were used to conduct Hedges-Olkin random effects meta-analysis on participants grouped by pain diagnosis (Hedges & Olkin, 1985). Hedges and Olkin's method of meta-analysis uses a pooled variance estimate to standardise the difference between group means. Biases were corrected based on a sample size statistic using weighted scores (as above).

A Q statistic was calculated to obtain a test of the homogeneity of the effect size (the extent to which individual effect sizes vary around the mean effect size); it is the standardised sum of squared differences between each effect size and the mean effect size:

$$Q = \sum_{i=1}^{k} \frac{(d_i - d_+)^2}{\hat{\sigma}_{d_i}^2}$$

where k is the number of studies or samples included, d_+ is the average effect size, and σ^2_d is the weighted average based on the variance of the unbiased effect sizes

Exploration of the heterogeneity of the mean PCS score across studies

The I^2 measure of heterogeneity was calculated for the grand mean PCS score and for the mean PCS score of diagnostic subgroups. It was necessary to transform the Q value reported in the original meta-analysis to an I^2 value owing to Q having 'too much power as a test of heterogeneity if the number of studies is large' (Higgins & Green, 2011, 9.5.2).

The I^2 value was calculated from Q as follows:

$$I^2 = \frac{(Q - df)}{Q}$$

SPSS version 23 (IBM Corp., 2015) was used to conduct random-effects meta-analysis and metaregressions. Multivariate metaregression was conducted to explore the heterogeneity of mean PCS scores across participant groups by testing their association with variables and other study features.

Meta-analysis to establish the stability of PCS scores across participant groups

It was hypothesised that participants with different pain diagnoses could show different levels of pain catastrophising. Meta-analytic techniques were therefore planned to apply to subsets of the population to 'show which aspects of scope (i.e., which potential moderators) are truly important and which are only erroneously thought to be important', following the theory of data set out by Hunter and Schmidt (2004, p.516). The potentially mediating moderators were those for which demographic data was

available: age, sex, and diagnostic status of participants, and the language of the PCS questionnaire used.

Establishing norms for participant subgroups

The thesis aimed to establish norms for participant subgroups based on pain diagnoses by conducting analyses to find weighted means and standard deviations for these groups. A sample size of 100 is the minimum recommended for generating normative data (Cole, 1990), therefore only groups with this minimum sample size were used.

Summary measures of mean PCS scores from studies, rather than raw PCS scores from individual participants, were used in the development of norms due to the nature of the data available from papers included in this review and meta-analysis.

Assessing construct validity of pain catastrophising as measured by the PCS

Correlations between PCS scores and scores on other psychometric measures found in the included studies were collected and entered into a database. A great number of psychometric scales for psychological constructs are used in research and clinical practice (Hatfield & Ogles, 2004). For this reason, the need for categories of correlations was anticipated. The categories used were based on psychological constructs, for example, anxiety, depression, and fear of pain. It was then aimed to calculate sample-size weighted average correlations between the PCS and other constructs using Hunter and Schmidt's procedures (2004). However, owing to great differences between correlations within construct categories, it was not feasible to continue with this analysis. Instead, the analysis focused on individual scales for which there were sufficient correlations to conduct meta-analysis.

Correlation coefficients were converted to Fisher's z scores for analysis. This is because the variance of the correlations is needed to perform meta-analysis, and the variance of r scores depends too strongly on the correlation itself and is therefore unsuitable

(Borenstein, Hedges, Higgins & Rothstein, p. 41). The transformation of r scores to Fisher's z scores was completed as follows:

$$z = 0.5\,x \ln\left(\frac{1+r}{1-r}\right)$$

Correlations converted to Fisher's z scores were then weighted by sample size as follows:

$$w_z = n - 3$$

where n is the sample size

Use of multiple regression to explore heterogeneity of PCS scores and correlations with other measures

Wilson's macro for SPSS (2006) was used to employ Hedges and Olkin's (1985) psychometric meta-analysis method on the correlations, with results transformed from Fisher's z scores back to r scores after the analysis. The meta-analytic results were used to assess homogeneity of the correlations and account for variance by calculating I^2 scores as above (see section 'Exploration of the heterogeneity of the mean PCS score across studies'). Hedges and Olkin's method of meta-regression uses a weighted least squares (WLS) procedure and uses scores from each study that are weighted by the inverse of the study's sampling error bias (this weighting and equation to find the weight are provided in the section 'Calculating weighted means, standard deviations and reliability alphas of PCS scores' above; see Hunter & Schmidt (2004, pp.388-390) for further discussion on different methods of meta-regression). Hedges and Olkin's method of meta-regression was chosen for this analysis because of its coherence with the theory of data used throughout: that including all available data and accounting for bias through weighting provides a more comprehensive analysis than excluding data. Variables entered into the first meta-regression were: pain category (type of pain diagnosis), mean age of participants, proportion of female participants, year of study (studies were categorised into ranges of three years), study type, and language of PCS used. A further meta-regression was then run using only the variables that were shown

to have a significant effect on PCS scores: pain category, study type, and language of PCS used. Re-running the meta-regression with these three variables also meant that more studies were included, because some studies were excluded on the grounds of missing data — including those with no data on the gender of participants — in the first meta-regression.

Linear regressions were run to analyse how much of the variance in correlations between the PCS and other measures is explained by the pre-specified variables of interest: study type, language, and diagnostic pain category of the participant group. Comparisons of the correlations between the PCS and measures of different constructs were used to comment on the construct overlap and the construct validity of the PCS.

Summary of the planned analysis

In summary, a systematic method was used to collect and prepare data on baseline PCS scores from multiple studies. The planned analyses aimed to use meta-analytic methods to explore the psychometric properties of the PCS; assess the sensitivity of the PCS to participant-level and other variables; establish norms for participant subgroups; and explore the construct validity of pain catastrophising as measured by the PCS.

Chapter 3: Results

Results are presented for the data search, collection and preparation process, followed by findings from the analyses conducted to meet the aims of this thesis.

Study selection

A total of 220 studies were identified for inclusion in the review and meta-analysis. The search of CINAHL, The Cochrane Library, EMBASE, PsycINFO, PubMed, and Web of Science database provided a total of 7,614 citations. After adjusting for duplicates 3,721 remained. Of these, 3,292 records were excluded at the title and abstract screening stage because they did not meet the inclusion criteria. The full texts of the remaining 429 studies were assessed for eligibility. Where articles appeared to be relevant but did not contain all relevant information, authors were contacted to request additional data. 209 articles were excluded because they did not meet the eligibility criteria or no response with required data was received from authors. Table 2 provides details of reasons for the exclusion of studies.

Table 2. Reasons for papers not included in the database at title/abstract and full text stages

Stage of screening	Number of papers excluded	Reason for exclusion
Abstract and title screening (total of 3,292 papers excluded at this stage)	1079	Not enough info in title/abstract to judge inclusion and exclusion criteria
	639	Not relevant (not a study/no use of PCS. Includes errata)
	437	PCS not used
	401	Conference or meeting abstract, not a paper
	355	Relevant review/meta-analysis/editorial comment/letter/theoretical paper
	210	Use of PCS, but for children/adolescents (under 18yrs); or child study (may or may not use PCS), or parent version of PCS
	100	Study protocol or dissertation abstract
	34	Data only (full paper coded separately)

	7	Book chapter or book review
	3	Uses 4-question version or another modified version of PCS
	2	Uses spouse version only (PCS-S)
	2	Uses a modified PCS
	1	Guidelines (not a study)
Full text screening (total of 209 papers excluded at this stage)		
	52	PCS scores not reported
	49	Meeting abstract
	22	Insufficient data
	22	Foreign language paper
	13	All or some participants were under 18 years old
	11	Duplicates data from another (included) study
	10	Modified version of PCS used
	9	Not a study (e.g. correction to a publication; figure; protocol only)
	6	No baseline
	5	Not peer reviewed
	4	Single case study
	3	Misuse of PCS (for example changes to instructions)

	2	Literature/systematic review
	1	Paper not retrieved
Data cleaning	1	Double counting of data (paper reporting data duplicating that of another paper)
	1	Implausible data (contains data above or below possible scores)
	1	Data double-counted

Inter-rater reliability of paper screening

Inter-rater reliability was calculated for the screening of papers that was completed by the two independent raters (CW and SM). There was 90.3% agreement, with a Cohen's kappa of .87 to account for agreement due to chance. The statistic meets the criteria for 80-100% agreement in order to be considered reliable inter-rater agreement (Field, 2013, p.56).

There was a total of 26 disagreements out of 186 papers screened by two reviewers. Of these, 19 were rated 'Yes' or 'Maybe' for inclusion in the meta-analysis by CW and 'No' by SM. In discussion between the reviewers, it was concluded that some of the papers would not meet inclusion criteria during full-paper screening, but that a conservative approach by CW of putting papers through to the next round of screening if in doubt was an appropriate strategy. Seven papers were rated 'Yes' or 'Maybe' by SM, and 'No' by CW. On further discussion, CW and SM agreed that the PCS was not used in four of the papers; two were conference or meeting abstracts; and one was a citation for a data source for a paper that was coded separately.

See Figure 3 for a flow diagram of the full study selection process.

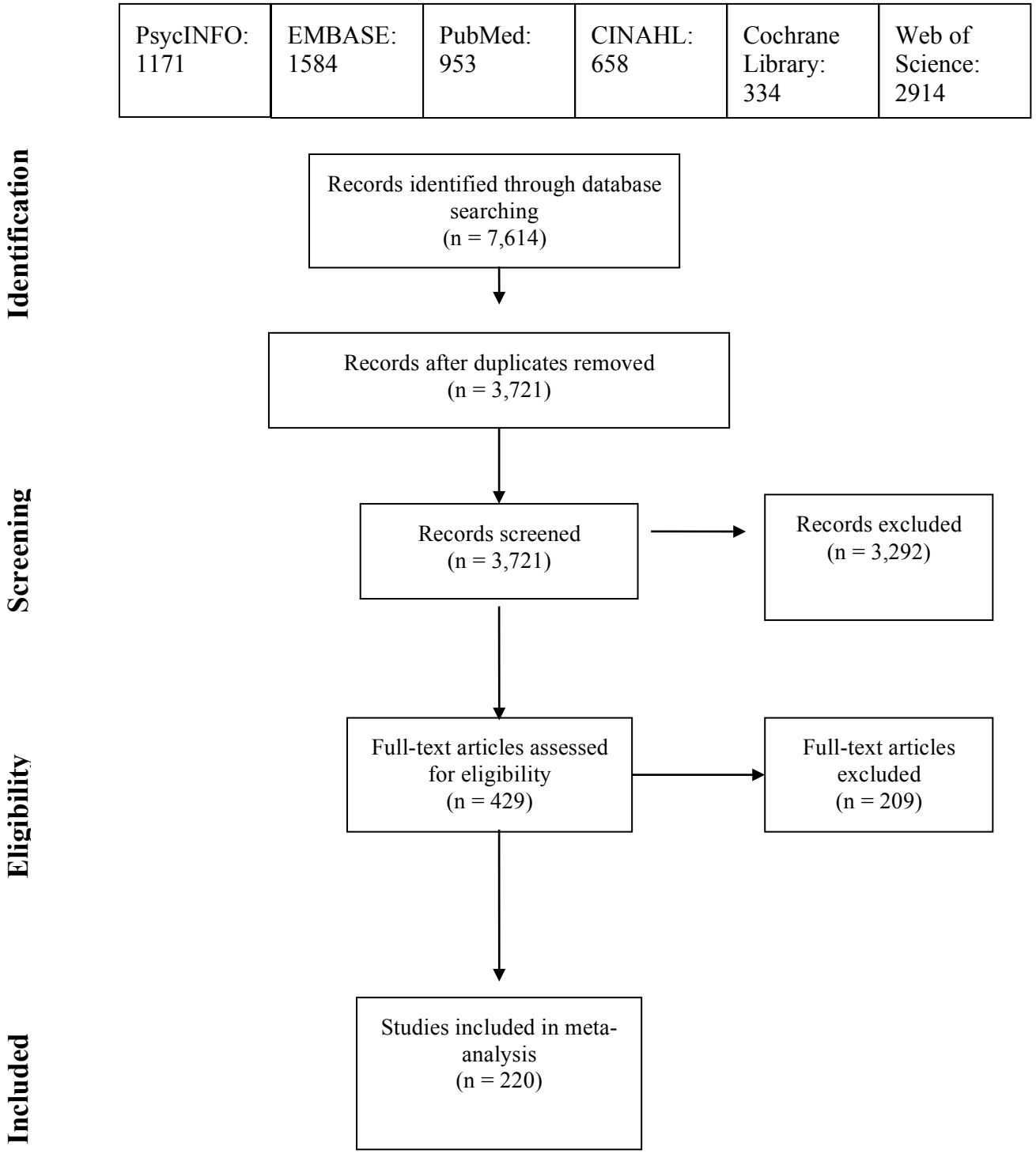

Figure 3. Flow diagram showing the searching and screening stages of papers to be included in the meta-analysis

Data cleaning

Data cleaning was conducted. One paper was removed on account of double counting of data. One paper was removed because data errors were found in the PCS mean score and standard deviation making the data unfeasible.

Several papers were found with surprisingly low PCS scores for pain participants (Bot, Anderson, Neuhaus, & Ring, 2013; Bot, Bossen, Herndon, Ruchelsman, Ring, & Vranceanu, 2014; Hegarty, Coakley, & Dooley 2014; Kim, Cho, Kang, Chang, Lee, & Yeom, 2015; Moseley, 2004; Rayahin et al., 2014; Tomkins-Lane, Lafave, Parnell, Rempel, Moriartey, & Andreas, 2015). These papers were not removed from the analysis; instead, the meta-analytic methods were applied to correct for artifacts and error (see 'Calculating weighted means, standard deviations and reliability alphas of PCS scores' in the Methods section).

Data preparation

Data preparation was conducted following guidelines from van den Berg (2013), with results as follows:

1. Case count and variable count: the original data contains 329 cases and 165 variables.
2. A unique case identifier variable was created for each sample ('Case_ID')
3. Undesirable variable types: Data on the year of publication of each study ('YrPub') was changed from Scale to Nominal and from String to Numeric (but not to Date because there was no available format for year without day or month). Data was transformed from string to coded (nominal) numeric for 'language', 'group type', and 'duplicate data' variables.
4. Specify missing values: missing data was specified as -999 (numerical) or NA (string)
5. Variables with many missing values: data on the mean age of participants was missing in 51 missing samples (14.2% percent of cases missing this variable); standard deviation of participants' age was missing in 61 samples (17% missing); gender distribution of sample was missing in 8.1% of cases; and Cronbach's alpha for the PCS was missing in 87.5% of cases. Missing data was

considered during the meta-analysis of data, with number of cases reported for each variable analysed.

6. Inconvenient distribution: many small categories were found on distribution tables particularly for correlations between the PCS and other measures, and for some of the diagnostic categories of participants. See 7 ‘Small categories’ below for fixing this problem
7. Small categories: 4 variables were removed that had no data (correlations of PCS with Edinburgh Postnatal Depression Scale, Fear Avoidance Beliefs Questionnaire, Five Facet Mindfulness Questionnaire, and Minnesota Multiphasic Inventory 2nd Edition). There are many other small categories in the database of correlations between the PCS and other measures: this highlighted a need to merge variables during meta-analysis. Only a few correlations have 7+ cases: HADS (anxiety and depression subscales), Numeric Rating Scale, Pain Disability Index, and the Tampa Scale of Kinesiophobia.
8. Undesirable coding: not applicable to this database (no reverse coding needed – and there are no ordinal variables)
9. Missing values per case: see point number 7 (‘Small categories’)

Three papers were found to contain data from the same population (Hooten et al., 2009; Hooten, Townsend, Bruce, Shi and Warner, 2009; and Hooten, Knight-Brown, Townsend, & Laures, 2012). The study by Hooten, Townsend, Bruce, Shi and Warner (2009) contained the largest sample size and therefore greatest weighting; for this reason, the other two studies were marked as ‘duplicate data’ and removed from analysis so that the overlap in participants would not affect data analysis.

Study characteristics

Data from 220 studies was included in the initial analyses. Studies were published between 1997 and 2015.

Methods

Included studies were cross sectional, psychometric, case series, randomised controlled and non-randomised controlled trials, case controlled, and cohort studies. All studies

used the PCS at baseline. The PCS translated into 21 foreign languages was used. Sample sizes ranged from 3 to 1,786. Many studies reported PCS scores and demographic data for two or more groups of participants; data was collected for 329 groups across the 220 studies.

Participants

Mean ages of participants in studies ranged from 19 to 76, with an unweighted grand mean age of 45 years, sd=12; and grand mean age weighted by sample size also of 45, sd=12.

The grand total number of participants across included studies was 42,976; this included 13,518 male participants and 23,824 female participants with the remaining 5,634 participants' gender not reported. Participant demographics are reported in Table 3.

Baseline PCS scores

Mean PCS scores across all participant groups ranged from 3.2 to 43.8, with a grand weighted mean of 20.22 using a random effects model (weighted SD = 10.26, 95% CIs of mean = 19.30-21.14, SE=.47, z=43.20, $p<.01$). Unless otherwise stated, 'PCS score' refers to the total scale score. Subscale scores are reported in some analyses, but subscale scores were reported in fewer papers (see section 'Internal consistency reliability').

Results of individual studies

Results of individual studies are presented in Appendix B due to the large number of studies (220) and larger number of participant groups in the studies (339).

Table 3. Demographic characteristics of participants in all studies included in the review

	Number of participants (n=42,976)	Percentage
Gender:		
Female	23,824	55.4
Male	13,518	31.5
Not reported (missing data)	5,634	13.1
Participant group:		
Healthy	7,742	18.0
Relatively generalized pain syndromes ('generalised pain')	3,404	7.9
Relatively localized syndromes of the head and neck ('head and neck pain')	1,036	2.4
Spinal and radicular pain of the cervical and thoracic regions ('cervical and thoracic pain')	916	2.1
Local syndromes of the upper limbs and relatively generalized syndromes of the upper and lower limbs ('upper or upper and lower limb pain')	2,874	6.7
Visceral and other syndromes of the trunk apart from spinal and radicular pain ('trunk pain')	1,157	2.7

Spinal and radicular pain syndromes of the lumbar, sacral, and coccygeal regions (‘lumbar pain’)	7,631	17.8
Local syndromes of the lower limbs (‘lower limb pain’)	1,412	3.3
Other (‘chronic pain’; mixed diagnoses)	16,804	39.1
PCS language version used:		
English	19,937	46.4
Dutch	8,720	20.3
Japanese	3,921	9.1
Spanish	2,841	6.6
Chinese	1,196	2.8
Croatian	985	2.3
French	773	1.8
Korean	755	1.8
German	753	1.8
Brazilian Portuguese	539	1.3
Danish	465	1.1
Norwegian	312	0.7
Malay	303	0.7
Arabic	300	0.7
Italian	268	0.6
Other (mixture of languages)	243	0.6
Cantonese	224	0.5
Turkish	165	0.4
Swedish	117	0.3
Greek	106	0.2
Africaans	41	0.1

English South African	33	0.1
Xhosa	19	0.0
Study type		
Cross sectional	15,471	36
Psychometric	8,595	20
Case series	7,306	17
Randomised controlled trial	3,868	9
Cohort study	3,438	8
Other	2,579	6
Case controlled study	2,149	5
Non randomised controlled trial	430	1

Risk of bias within studies

Three screening questions were used to assess the risk of bias within studies (see Table 4). 70 studies fulfilled criteria for all three screening questions. All but two studies fulfilled criteria for component 1. For component 2, eight studies recruited under 50% of the number of eligible persons for the study. The number of eligible persons could not be determined in 25 studies, most commonly as a result of participants being recruited through public advertisements. The reported number of eligible persons was not applicable in 17 studies as participants were recruited consecutively as a convenience sample. 95 studies did not report the number of eligible persons, for example, stating the number of healthy students who volunteered but not the total number of students who were invited to volunteer.

For component 3, 18 of the total 220 studies did not report inclusion and exclusion criteria or the time period of populations from which participants were selected.

A full table of quality measures of studies is presented in Appendix C.

Table 4. Summary of quality measures of the studies that failed to fulfill any one of the three markers of sample-related internal validity

Screening question	Response	No. studies
Q1	Y	218
	N	2
Q2	Y	75
	N	8
	CD	25
	NA	17
	NR	95
Q3	Y	202
	N	18

Notes: Y = yes (criterion fulfilled); N = no (criterion not fulfilled); CD = cannot determine; NA = not applicable; NR = not reported

Screening questions:

Q1 = Was the study population clearly specified and defined?
Q2 = Was the participation rate of eligible persons at least 50%?
Q3 = Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study pre-specified and applied uniformly to all participants?

The weighted PCS scores for all studies included in the review and for just those studies meeting all the risk of bias criteria were calculated (see Table 5 for results). The difference between the weighted mean PCS scores of all studies and just those meeting all risk of bias criteria necessitated further investigation.

Table 5. Weighted mean PCS scores and confidence intervals for all studies included in the meta-analysis and for studies meeting all risk of bias criteria

Included studies	N	Weighted mean PCS score	95% CI	Weighted sd of PCS score	95% CI
All studies	220	20.22	19.30-21.14	10.26	10.02-10.50
Studies meeting all risk of bias criteria	70	22.78	20.94-24.61	10.79	10.44-11.15

A subgroup analysis was conducted to determine the difference in PCS scores between studies that did and did not meet all of the risk of bias criteria; results are presented in Table 6.

Table 6. Weighted mean PCS scores and confidence intervals for studies meeting all risk of bias criteria and for studies that did not meet all risk of bias criteria

Included studies	N	Weighted mean PCS score	95% CI	Weighted sd of PCS score	95% CI	P-value
Studies meeting all risk of bias criteria	70	22.78	20.94-24.61	10.79	10.44-11.15	<.05
Studies not meeting all risk of bias criteria	150	19.13	18.19-20.06	10.03	9.73-10.34	

Regression analysis was carried out to determine the significance of the difference between scores. Whether or not a study met all risk of bias criteria was significantly related to the PCS score, B=16.64, SE=0.49, 95% CI=15.68-16.60 , p<0.001. Analysis of variance showed a significant correlation between the type of study conducted and

whether or not the study met all risk of bias criteria, B=5.62, SE=0.12, 95% CI=5.38-5.85, $p<.05$.

Meta-analysis to explore the psychometric properties of the PCS

Meta-analytic methods were used to assess data from multiple studies, aiming to provide more accurate data on psychometric properties of the PCS than that found in single studies.

Measuring the heterogeneity of the grand mean PCS score

The I^2 value of the grand mean PCS score is 98.96%, meaning there is nearly 99% variation across studies that is due to heterogeneity rather than chance. The high I^2 value might also suggest that the overall mean ES is misleading because there are subpopulations of studies represented that have different ES values; this supports the need to conduct subgroup analysis to further determine the origins of heterogeneity of mean PCS scores across participant groups. A forest plot of the weighted mean PCS scores and confidence intervals of all participant groups is presented for reference in Appendix D due to the large number of groups (k=339).

Reliability

Two types of reliability statistic were collected from the studies included in this meta-analysis: internal consistency and test-retest reliability of the PCS.

Internal consistency reliability

Estimates of the internal consistency reliability of the total PCS and PCS subscales based on the meta-analysis of studies included in this review are presented on the left hand side of Table 7. All estimates were based on Cronbach's coefficiency alpha (Cronbach, 1951). A total of 40 studies reported coefficient alpha results. After weighting and averaging all studies, an alpha was found of .92 (95% CI .91 - .93).

The mean coefficients for the PCS subscales, based on alphas reported in 21 samples, were reasonably high with a mean range of .77-.89. The internal reliability of the magnification and helplessness subscales of the PCS were higher than expected based

on previous research (.77 compared with .66 and .78 compared with .88 in Sullivan et al., 1995). The magnification subscale obtained a score of .53 in one study, but this did not appear to be a distant outlier as four other studies reported scores in the range .64-.67. In summary, the whole scale PCS possesses excellent internal consistency reliability. Subscales of the PCS possess acceptable (magnification subscale) to good (rumination and helplessness subscales) internal consistency reliability.

Table 7. Weighted mean, confidence intervals and range of reliability scores across studies on the total PCS scale and subscales

	Internal reliability				Test-retest reliability			
	K	Wt_M	95% CI	range	K	Wt_M_t	95% CI	range
Total PCS	40	.92	.91-.93	.82-.98	8	.88	.83-.93	.73-.97
Rumination subscale	21	.89	.87-.91	.81-.99	n/a	n/a	n/a	n/a
Magnification subscale	21	.77	.73-.82	.53-.99	n/a	n/a	n/a	n/a
Helplessness subscale	21	.88	.86-.90	.76-.98	n/a	n/a	n/a	n/a

Notes:
K = number of samples
Wt_M = weighted mean of Cronbach's α scores
Wt_M_t = weighted mean of test-retest reliability scores

Test-rest reliability

A total of 8 samples (n = 317) from six included studies were weighted and then combined to produce a mean test-retest reliability alpha of .88 (95% CI .83-.93), representing good reliability. The time lapse between the test and retest in included samples ranged from 7 to 135 days. Five samples had a standardised interval of either 7 or 28 days between test and retest of the PCS; while the other three samples each had a

range of intervals between the tests. Two of these were within a week and a month, however the third ranged between 14-135 days.

Meta-analysis to establish the stability of PCS scores across participant groups

Assessing the heterogeneity of PCS scores between subgroups of participants

Participants from studies included in this meta-analysis were categorized based on their pain diagnosis. Participants in the 'other' group did not fit into one of the pre-specified pain diagnosis categories. A forest plot showing the weighted mean PCS scores of participant groups by pain category is presented in Figure 4. The wide spread between branches in the plot suggests a great amount of heterogeneity in the PCS scores found across participant groups. No grand total line is displayed in the forest plot because of the amount of heterogeneity. Notably, participants with lower limb pain experienced, on average, lower pain catastrophising than healthy participants by two points out of a possible score of 52 on the PCS. The 95% confidence intervals for the mean PCS scores of participants with upper limb or upper and lower limb pain also ranged from lower than those of healthy participants. The heterogeneity of scores was explored further using subgroup analysis.

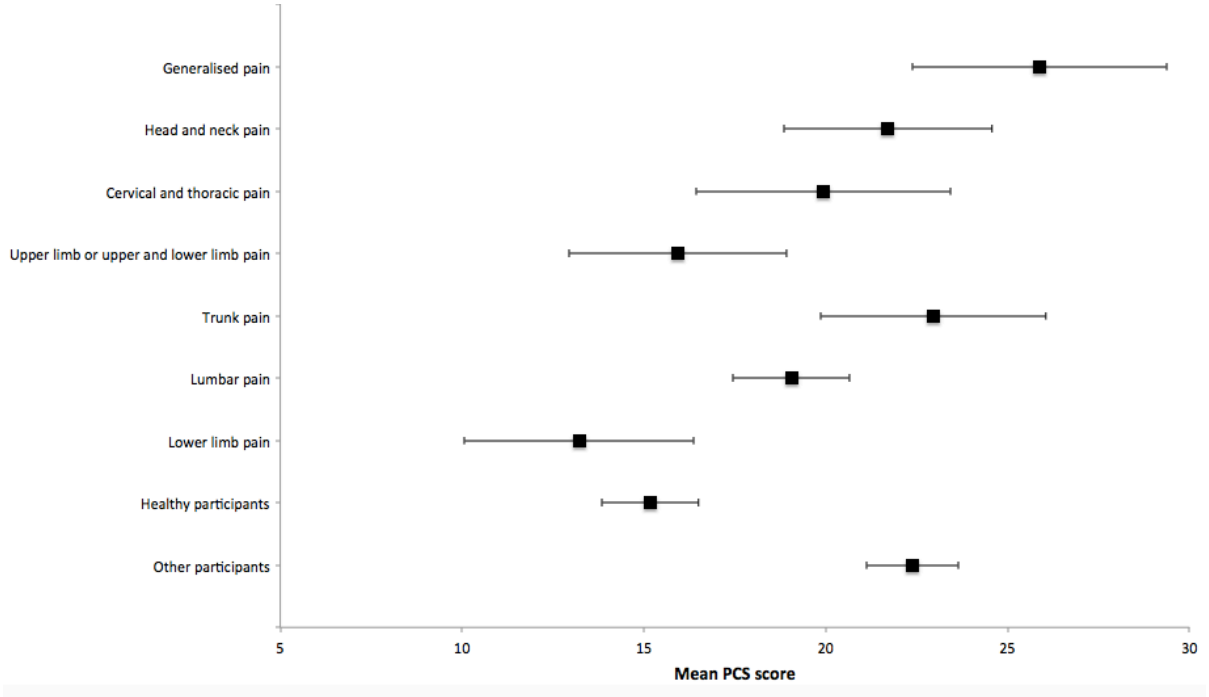

Figure 4. Forest plot showing the weighted mean ES and confidence intervals of PCS scores for groups of participants based on pain diagnosis

Subgroup analysis of PCS scores

Owing to wide heterogeneity between PCS scores of participants with different pain diagnoses, subgroup analysis was conducted to establish the heterogeneity of scores within these diagnoses. Table 8 displays the I^2 value to describe the percentage of variability within diagnoses that was due to heterogeneity rather than sampling error (Higgins & Thompson, 2002).

I^2 values ranging from 92.27% to 99.04% indicate high levels of heterogeneity within all diagnostic groups. Notably, a large number of participants fell under 'other'/healthy/groups with mixed or unclear diagnoses such as 'chronic pain' (193 groups; 24,546 participants).

Table 8. Heterogeneity of PCS scores within subgroups of participants based on pain diagnosis

Participant category	No. participant groups in review	No. participants	Q	df	p	Heterogeneity (I^2)
Generalised pain	34	3,404	3427.65	33	<.0001	99.04%
Head and neck pain	14	1,036	363.82	13	<.0001	96.43%
Cervical and thoracic pain	10	916	189.58	9	<.0001	95.25%
Upper or upper and lower limb pain	15	2,874	181.12	14	<.0001	92.27%
Trunk pain	11	1,157	224.00	10	<.0001	95.54%
Lumbar pain	46	7,631	1864.20	45	<.0001	97.59%
Lower limb pain	6	1,412	151.09	5	<.0001	96.69%
Healthy	69	7,742	3429.03	68	<.0001	98.02%

participants	
Other	16,804

Meta-regression of PCS scores

Multivariate metaregression analysis was conducted to establish the association between PCS scores and dependent variables. Variables included in the analysis were diagnostic pain category, language of PCS, type of study, age of participants, gender of participants, and year of study publication. The number of participant groups included in the analysis was 277, with several groups excluded due to missing data. Results showed that the diagnostic category of participants, the language of the PCS administered, and the type of study conducted were all significantly associated with the mean PCS score obtained (see Table 9). There was a very slight negative effect of age on PCS score (-.087) but it did not reach significance (p=.077). There was no significant effect of gender on PCS scores using the available data of gender percentages within studies. There was no significant effect of year of publication on PCS scores. The significant effect of type of study on PCS scores suggests that methodological error could be a contributing factor to the heterogeneity of PCS scores.

Table 9. Association between covariates in meta-regression and the grand mean PCS score

Variable	Significance level
Diagnostic category of participants	<.001
Language of PCS administered	<.001
Year range of publication*	.096
Type of study	<.001
Mean age of participants	.077
Percentage of female participants	.360

*** Year of publication was categorized into groups of 3-year duration**

A further meta-regression analysis was conducted with the variables of diagnostic category and language of PCS administered, as these variables can be used as predictive factors in clinical practice. The purpose was to include more participant groups by running the meta-regression with fewer variables. 329 participant groups were included in this analysis (there was no missing data for these variables). Table 10 shows that most – but not all – diagnostic pain categories have significantly higher PCS scores than healthy participants. The exceptions were upper or upper and lower limb pain, and lower limb pain. Generalised pain and trunk pain diagnoses was associated with markedly higher PCS scores than for healthy participants.

Significant variations in other languages versus English language PCS scores included markedly higher scores in participants using the Cantonese version of the PCS (β 15.31, $p = .002$). In terms of Western-origin versus non-Western-origin languages, Brazilian Portuguese and Chinese language versions of the PCS produced significantly different scores to the English version ($\beta = 9.88$, $p = .004$ and $\beta = 6.97$, $p = .001$ respectively), whereas Japanese, Xhosa, Malay, and Africaans versions did not. Additionally, Dutch, Spanish, and Croatian versions resulted in significantly different scores from the English version ($\beta = -4.42$, $p < .001$; $\beta = -3.68$, $p = .002$; and $\beta = 5.09$, $p < .05$ respectively). Therefore differences in PCS scores of different language versions were not concluded to be a result of differences between Western and non-Western language or culture.

Table 10. Regression of variables onto the grand mean PCS score

	Univariate model	Weighted least squares meta-regression model				
			95% confidence interval			
Variable	p	β	Lower bound	Upper bound	t	p
Diagnostic category of participants	<.001					
Healthy		Index				
Generalised pain		17.803	15.225	20.381	13.590	.000
Head and neck pain		6.680	2.758	10.602	3.352	.001
Cervical and thoracic pain		5.633	.619	10.647	2.211	.028
Upper limbs or upper and lower limb pain		-4.201	-6.814	-1.587	-3.163	.002
Trunk pain		11.209	6.578	15.841	4.763	.000
Lumbar pain		4.963	2.776	7.150	4.467	.000
Lower limbs		-1.036	-4.831	2.730	-.541	.589
Other or mixed diagnosis		6.389	4.618	8.160	7.100	.000
Language of PCS administered	<.001					
English		Index				
Other/multiple languages		-6.272	-16.944	4.399	-1.157	.248
French		-.916	-6.707	4.874	-.311	.756
Dutch		-4.420	-6.109	-2.731	-5.149	.000
Korean		1.645	-3.645	6.936	.612	.541

Norwegian	-4.147	-11.332	2.838	-1.168	.244
Spanish	-3.684	-6.036	-1.332	-3.083	.002
Chinese	6.967	2.738	11.195	3.242	.001
German	-.926	-6.142	4.290	-.349	.727
Italian	2.519	-4.331	9.368	.724	.470
Japanese	5.375	2.827	7.923	4.151	.000
Greek	1.169	-14.991	17.330	.142	.887
Swedish	-1.301	-11.191	8.588	-.259	.796
Danish	-2.724	-8.311	2.863	-.959	.338
Croatian	5.092	.634	9.549	2.248	.025
Brazilian Portuguese	9.883	3.123	16.643	2.877	.004
Malay	4.601	-3.191	12.393	1.162	.246
Xhosa	1.798	-23.782	27.378	.138	.890
English South African	5.798	-20.456	32.053	.435	.664
Africaans	4.598	-18.776	27.973	.387	.699
Cantonese	15.312	5.707	24.917	3.137	.002
Turkish	-4.898	-16.660	6.863	-.820	.413
Arabic	8.297	-.713	17.307	1.812	.071

Analysis of study types

Subgroup analysis was conducted to explore the differences in PCS scores between different study types. Figure 5 shows the mean PCS scores and 95% confidence intervals for the different study types included in this review and meta-analysis. The study types showed considerable overlap and homogeneity in mean PCS scores, with the exception of non-randomised controlled trials which had a higher mean PCS score, and ‘other’ study types which had a lower mean PCS score. RCTs also had a slightly higher PCS score than most other study types.

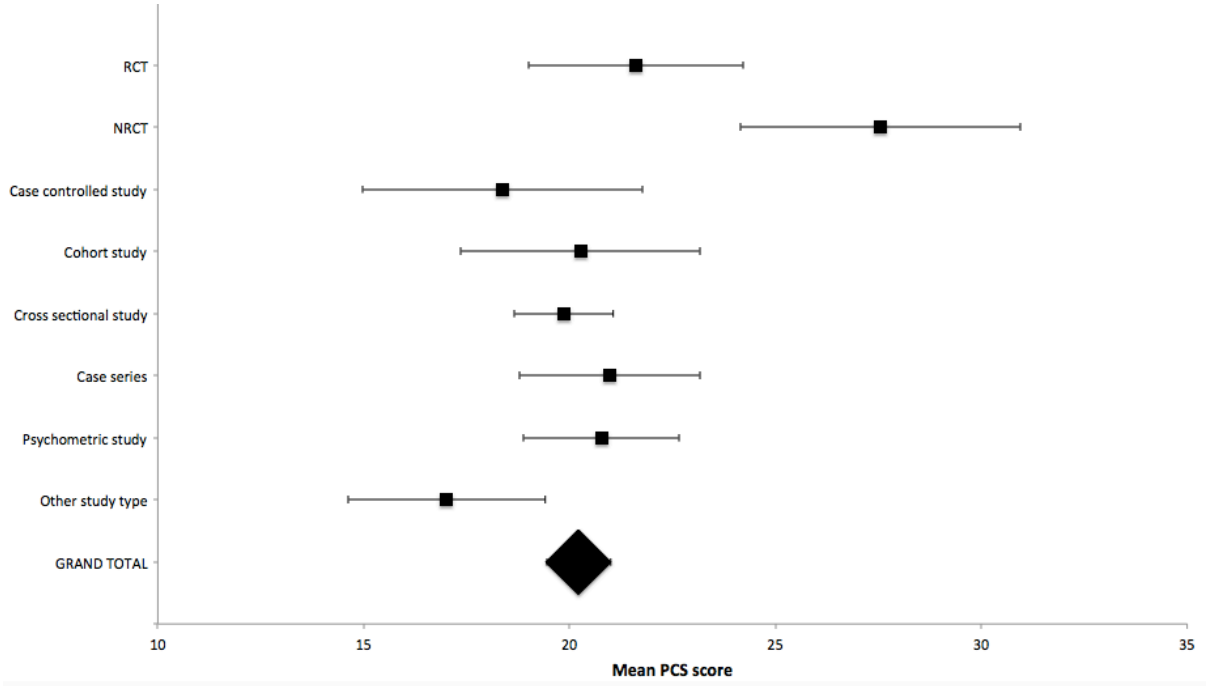

Figure 5. Forest plot showing the mean PCS scores and 95% confidence intervals for subgroups of samples based on study type

Note: RCT = randomised controlled trial; NRCT = non-randomised controlled trial

Establishing norms for participant subgroups

Normative values (norms) were constructed for each of the pain diagnostic groups as categorized in this review. The weighted mean PCS score for each diagnostic group was used to calculate a norm value. Norms are presented with demographic data to provide context on the sample population. Norms tables are presented in Appendix E.

Assessing the construct validity of pain catastrophising as measured by the PCS

The evaluation of construct validity requires correlations between the PCS and other measures of pain catastrophising in order to assess convergent validity, and correlations between the PCS and other constructs in order to assess divergent validity.

232 correlations between the PCS and 123 other outcome/self-report measures were retrieved from studies included in the meta-analysis, with frequencies as follows:

10 separate correlations: found for 1 measure

9 correlations: 3 measures

7 correlations: 1 measure
5 correlations: 4 measures
3 correlations: 7 measures
2 correlations: 19 measures
1 correlation: 87 measures

The high frequency of measures with only one correlation reported in one study confirmed the need to create correlate categories of wider constructs. This aligned with the observation that many measures overlapped in the constructs that they measured. Table 11 reports the wider construct categories, measures used in studies in the meta-analysis, and the range of correlations found between the PCS and other measures. A total of 62 measures were included in the categories in Table 11; all remaining measures could not be included because they measured unrelated constructs or a mixture of constructs such as anxiety and depression within a single scale.

Table 11. Range of correlations and measured used for each construct in included studies

Construct	Measures included	No. groups	Range of correlations
Pain catastrophising (from other measures)	Coping Strategies Questionnaire - catastrophising subscale Visual Analogue Scale – catastrophising subscale	2	.19 to .8
Kinesiophobia (fear of moving)	Tampa Scale of Kinesiophobia Tampa Scale of Kinesiophobia short 11-item version Visual Analogue Scale – kinesiophobia subscale	9	.02 to .68
Anxiety	Anxiety Sensitivity Index Depression, Anxiety and Positive	26	.12 to .81

	Outlook Scale – anxiety subscale Experiences in Close Relationships Questionnaire - model of self (anxiety) Hospital Anxiety and Depression Scale - anxiety subscale Pain Anxiety Symptoms Scale Pain Anxiety Symptoms Scale, short form State-Trait Anxiety Index (state and/or trait subscale) Visual Analogue Scale – anxiety subscale		
Depression	BDI original version published in 1961 BDI-II Depression, Anxiety and Positive Outlook Scale Geriatric Depression Scale - 15 item version Hospital Anxiety and Depression Scale - depression subscale Patient Health Questionnaire Visual Analogue Scale depression subscale ZUNG depression scale Centre for Epidemiological Studies - Depression Scale	22	.26 to .68
Disability/limited function	Arthritis Self-Efficacy Scale - function subscale Chronic Pain Self-Efficacy	38	.18 to .65

	Questionnaire, physical function		
	Disabilities of the Arm, Shoulder and Hand scale		
	Disability Rating Index		
	Fear Avoidance Beliefs Questionnaire physical activity scale		
	Fear Avoidance Beliefs Questionnaire work scale		
	Fibromyalgia Impact Questionnaire, physical index		
	Neck Disability Index		
	NeckPix		
	Oswestry Disability Index		
	Pain Disability Index, home subscale		
	Pain Disability Index, life subscale		
	Pain Disability Index, occupation subscale		
	Pain Disability Index		
	Pain Disability Index, recreation subscale		
	Pain Disability Index, social subscale		
	Pain Disability Index, sex subscale		
	Pain Disability Index, self subscale		
	Pain Disability Questionnaire		
	Patient Specific Functional Scale		
Pain intensity	BDI pain intensity subscale	22	.15 to .69
	Chronic Pain Grade, Characteristic Pain Intensity Score		
	Graphic Rating Scale of pain intensity in the last week		
	McGill Pain Questionnaire - Present		

	Pain Intensity		
	McGill Pain Questionnaire - Pain Rating Index		
	Numeric Rating Scale of pain intensity		
	Pain Visual Analogue Scale		
	SF-36 Bodily Pain Scale		
	SF-36 Bodily Pain Scale mental subscale		
	SF-36 Bodily Pain Scale physical subscale		
	SF-36 Bodily Pain Scale role physical score		
Pain management/coping	Chronic Pain Self-Efficacy Questionnaire, coping with symptoms	2	-.15 to -.36
	Chronic Pain Self-Efficacy Questionnaire, pain management		
Fear of pain	Fear of Pain Questionnaire	5	.34 to .48
	Fear of Pain Questionnaire short form 9 items		
Sexual function/satisfaction	Female Sexual Function Index	2	-.23 to -.24
	Global Measure of Sexual Satisfaction		
Attention to pain	Pain Vigilance and Awareness Questionnaire - attention to changes in pain	2	.23 to .68
	Pain Vigilance and Awareness Questionnaire - attention to pain		

Pain acceptance	Chronic Pain Acceptance Questionnaire	3	-.46 to -.67

The planned Hunter-Schmidt method of meta-analysing correlations is appropriate for 30 or more samples (Field, 2001). The construct of disability/limited function had 38 correlations in included studies, but the range of correlation scores was wide (.18 to .65) and not due to outliers as scores were reasonably spread across this range. For this reason, calculating a summary mean correlation for this construct was not deemed appropriate.

The construction of a correlation matrix (following Campbell & Fiske, 1959) would have required summary statistics from multi-trait and multi-method measures. The multi-method scores were to include the PCS as one measurement correlated with other questionnaire measures of pain catastrophising. Two correlations were found between the PCS and the pain catastrophising subscales of the Coping Strategies Questionnaire and the Visual Analogue Scale (.8 and .19 respectively). The vast difference between these correlations hampers attempts to combine them into a 'pain catastrophising' summary statistic or to use them separately to evaluate the convergent validity of the pain catastrophising construct. Similarly, heterogeneity of correlations within other construct categories (see Table 11) makes it impractical to use these correlations to evaluate discriminant validity between pain catastrophising and other constructs.

The Pain Catastrophising Scale uses some items from the pain catastrophising subscale of the Coping Strategies Questionnaire (Sullivan et al., 1995, p.5). Therefore it was not feasible to treat the PCS and CSQ subscale as separate methods of measuring pain catastrophising. Additionally, there was only one correlation in the collected data between the PCS and the CSQ subscale, meaning meta-analytic techniques could not be applied.

Linear regression was conducted to further explore the origin of variance in the correlations found for the PCS and the McGill Pain Questionnaire: Pain Rating Index. This analysis was only carried out on the correlations between these two measures because they were the only pairing to have ten correlations: regression requires at least

ten studies for each moderator used in the analysis (Higgins & Green, 2011). In figure 6, the top line shows that 23% of the total variance in correlation coefficients between the PCS and McGill Inventory was within studies and 77% was between studies. The bottom line demonstrates that 59% of variance is explained by the type of study conducted, with very little variance explained by language and the pain diagnostic group of participants. This suggests a large amount of variability due to potential methodological biases and error in data collection. 35% of variance is left unexplained.

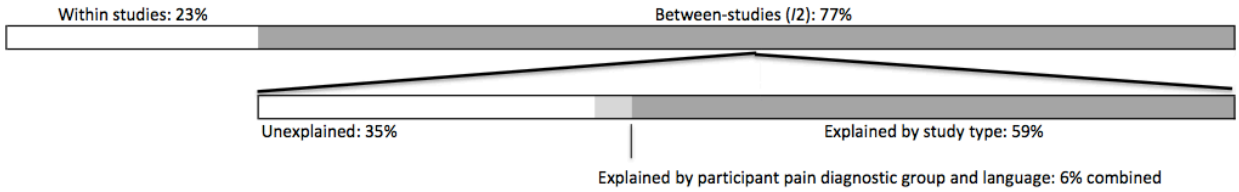

Figure 6. Proportion of within studies variance and between studies variance in correlations between the PCS and McGill Pain Questionnaire: Pain Rating Index explained by the variables type of study, language of PCS, and diagnostic group of participants

Table 12 demonstrates the variance of the correlations between PCS and the measures most commonly used in the included studies; but caution is advised when interpreting the scores when fewer than 10 correlations were found (this was the case in all but between the PCS and McGill Pain Questionnaire: Pain Rating Index).

Summary of results

Results from meta-analysis used in this thesis confirmed high internal validity and test-retest reliability of the PCS. The stability of the PCS across variables of participant pain diagnosis and language of the questionnaire was brought into question, with high heterogeneity of scores between groups. Differences in PCS scores between participant groups supported the need to develop norms for subgroups of people based on pain diagnosis; norms were established in this thesis from available data. The construct validity of pain catastrophising was explored as far as possible given available data, with some evidence of divergent validity of pain catastrophising and other pain-related constructs established.

Table 12. Correlations and heterogeneity of correlations between the PCS and other measures

Correlation between the PCS and which measure	No. participant groups in review	No. participants	Mean r	95% CI lower	95% CI upper	Q	df	p	Heterogeneity (I^2)
McGill Pain Questionnaire: Pain Rating Index	10	785	.42	.29	.55	39.52	9	<.001	77%
Tampa Scale of Kinesiophobia	7	1373	.39	.15	.59	74.27	6	<.001	92%
HADS: Anxiety subscale	8	1175	.49	.39	.58	32.86	7	<.001	79%
HADS: Depression	8	1175	.49	.42	.55	12.71	7	.080	45%

Numeric Rating Scale of Pain Intensity	6	513	.36	.28	.44	.83	5	.975	n/a
Pain Disability Index	9	2366	.48	.41	.55	20.21	8	.010	60%

Chapter 4: Discussion

Review of background and aims of the thesis

Many self-report measures are used in clinical psychology and other disciplines, and they tend to be developed and used in an ad-hoc way, without thorough validity and reliability tests across wide samples of participants (Morley, in press, p.18). Construct validity has also been called into question, with an ever-increasing number of psychological concepts alongside suggestions that some concepts may overlap (McCracken & Morley, 2014). Pain catastrophising is one such concept, with questions as yet unanswered regarding its exact relationship with other pain-related constructs such as fear of pain and pain-related anxiety, and differentiation from the wider concept of depression. The PCS is an example of a widely used measure of pain catastrophising. Existing psychometric evidence for the validity and reliability of the PCS is based on single studies and limited participant groups such as students (Osman et al., 1997) and community and pain outpatients (Osman et al., 2000). The aims of this thesis were to systematically obtain data on PCS scores from a wide range of studies and to explore the psychometric properties of the PCS using meta-analytic methods. PCS scores across studies were used to assess the sensitivity of the scale to different participant factors, to explore the construct validity of the scale, and to establish more accurate norms for participant groups based on pain diagnoses. In meeting these aims, this thesis demonstrates the potential for the use of meta-analysis to establish psychometric properties of self-report measures in clinical psychology.

Summary of evidence

Data obtained

The thesis included 200 studies of a total of 329 participant groups with a mixture of pain diagnoses, age, and gender distributions. PCS scores from 42,976 participants were included in this review. This represents a considerable database from which to conduct psychometric meta-analysis.

Use of PCS

The data collected confirmed that the PCS is used worldwide and across pain and healthy populations, for research and clinical purposes. The PCS was used in a range of study types.

Psychometric properties of the PCS

Meta-analytic methods were used to establish and refine the known psychometric properties of the PCS. Good internal consistency reliability and test-retest reliability were confirmed in this meta-analysis. This supports the properties of the PCS reported in the initial study by Sullivan et al. (1995) on the development of the scale. Cronbach's alpha reliability scores for the PCS total scale and subscales, in Sullivan's paper and in this thesis respectively, were as follows: total scale = .87 and .92; rumination subscale = .87 and .89; magnification subscale = .66 and .77; helplessness subscale = .78 and .88. The lower reliability score for magnification compared to the other subscales may be explained by fewer items in the subscale (three items compared to four and six in the rumination and helplessness subscales).

Test–retest reliability of the PCS was reported as .75 after six weeks and .70 after 10 weeks in a healthy student population in the original PCS manual (Sullivan et al., 1995). The higher score of .88 found in this meta-analysis could be interpreted in a number of ways. The majority of participants repeated the PCS with a shorter interval in the included samples (75% of participants definitely completed the retest questionnaire within a month of completing the first questionnaire). A shorter interval might be expected to result in higher stability of the pain catastrophising construct, with less change expected to occur in a shorter time frame. In contrast to participants in Sullivan et al. (1995), those included in the current meta-analysis were from both clinical and non-clinical samples, suggesting that the construct of pain catastrophising is perhaps more stable in a clinical population.

Internal reliability and test-retest reliability scores are reported with the caveat of great heterogeneity between PCS scores across studies and across subgroups of participants.

The implications of this heterogeneity are discussed below.

Stability of the PCS across participant groups

Subgroup analysis was conducted to further investigate reasons for heterogeneity in PCS scores between pain diagnostic groups, and to explore the effects of different variables on PCS scores. The lack of significant effects for age and gender of participants on PCS scores adds evidence to existing discussions around these factors. Individual studies have resulted in contradictory results regarding the direction of the effect of age on PCS scores (see Introduction). The non-significant effect of age on PCS scores found in this meta-analysis could explain the existence of contradictory results within single studies.

The significant difference made by language of the PCS used to the PCS scores reported is suggestive of a cultural or linguistic impact on pain catastrophising. Data was not consistently available to distinguish the ethnicity of participants or, sometimes, even the country of the study (some studies were conducted in multiple countries). Psychometric studies have been conducted to assess the validity and reliability of different language versions of the PCS; many of these papers were included in this meta-analysis. The varying results of PCS scores between language versions could illustrate linguistic or cultural differences in the measurement of pain catastrophising. Possible reasons for divergent PCS scores include linguistic nuances in the description of pain catastrophising and translations of questionnaire items; cultural differences in experiencing or reporting pain catastrophising; and differences in participant populations sampled. Further research would require consistent data on the PCS language used and also the cultural background of participants in order to differentiate the impact of language and of culture on levels of pain catastrophising.

The difference in PCS scores between participants with different pain diagnoses could indicate a number of points. Firstly, it is possible that different pain diagnoses are associated with different levels of pain. This is supported by evidence that pain catastrophising increases with increased pain intensity reports (Quartana et al., 2009). Alternatively, the rumination, helplessness and magnification in catastrophising could

be affected by other differences between pain diagnoses. Participants with generalised pain had the highest PCS scores: this could be explained by potentially higher levels of helplessness in participants with a pain condition with no targeted cure. Perhaps the most surprising result was that participants with lower limb or upper and lower limb pain conditions had lower PCS scores than healthy participants. This could be due to errors in measurements such as the difference scores found in different study types. Alternatively, differences in pain catastrophising could be due to other factors such as the onset, nature, and prognosis of the pain. Participants with limb pain are more likely to have acquired the pain as a result of trauma than participants with, for example, generalized pain which is often reported at multiple body areas (Davies, Crombie & Macrae, 1998). Trauma-related pain follows a different expected trajectory for recovery from generalized or chronic pain conditions, although the two are not mutually exclusive as it is possible for trauma pain to become chronic (for example, see Perkins & Kehlet, 2000). This is one potential reason for differences in pain catastrophising scores: people in recovery from trauma-related pain may have different expectations about their future with pain compared with those for whom no 'cure' for the pain is expected. Further research could differentiate pain catastrophising scores between participants with different pain prognoses.

PCS scores across study types

Multivariate regression demonstrated that the type of study had an effect on the mean PCS score found. Subgroup analysis on study type indicated that NRCTs had higher than expected PCS scores, while 'other' study types had lower than expected scores. A slightly higher mean PCS score for RCTs compared to most study types is perhaps not surprising, given that RCTs typically involve a clinical sample as well as a healthy or control group, whereas some of the other study types such as psychometric studies typically were more likely to recruit healthy participants. The mean PCS score for NRCTs was based on just two participant groups from one study (Riddle, Keefe, Nay, McKee, Attarian, & Jensen, 2011). The study recruited participants scheduled for knee replacement surgery, who were therefore likely to be experiencing high pain intensity. Furthermore, participants were recruited only if they 'reported high levels of pain catastrophising' (p.859) which were set at a score of 16 or higher on the PCS. The

higher PCS score on NRCTs is therefore a result of this recruitment strategy rather than to do with the design of NRCTs in general. This finding supports the use of weighted scores in further analysis conducted for this thesis, which helped to minimize the effect of methodological biases. Additionally, sensitivity analysis was conducted to explore and acknowledge biases in sampling strategies in included studies. 'Other' study types included 21 participant groups, and consisted of experimental studies with no control group. 17 out of 21 of the participant groups in the 'other' study type were healthy participants, which could explain the lower PCS score for this study type. Although study type was identified as a significant factor contributing to PCS scores, the recruitment strategy and participant pain group appear to contribute to the PCS scores rather than other methodological considerations.

PCS norms for participant subgroups

The difference in mean scores for different participant groups suggests that the 75% cut-off score for clinical significance is likely to vary between groups. This means that the clinical threshold of a score of 30 set by Sullivan et al. (1995) is likely to vary across groups. However, without the availability of raw PCS scores, it was not possible to calculate percentage rankings.

Norms established in this meta-analysis made progress towards meeting Anghoff's (1984) conditions for accurate and clinically useful norms. The meta-analysis confirmed the conditions of the characteristics of the PCS as an ordinal scale with reasonable construct validity and internal validity. The samples used for norms from this thesis were broadened compared the sample in Sullivan et al. (1995) to include a much greater number of participants from different studies, countries, using different language versions of the PCS. Participants were categorized into pain diagnosis groups to make the norms more specific and clinically relevant, meeting the criterion that 'data should be made available for as many distinct norm populations as there are populations with which it is useful for an individual or group to be compared' (Sullivan et al., 1995). Although the norms established in this thesis were not based on raw scores and therefore could not be used to create percentile data, they still provide context for scores obtained in clinical practice. For example, a person with trunk pain scoring above 23 on

the PCS full scale would be known to be above average in pain catastrophising for people with similar pain diagnoses. Although this information can be used to help with interpretations of an individual's PCS scores, it does not provide evidence for clinical cut-offs and predictive meaning of the level of pain catastrophising. For example, the threshold level of catastrophising that means an individual is likely to experience higher levels of pain, chronicity of pain, level of disability, and overall prognosis has not been established for these norms. For this reason, it is not recommended that these norms are used for clinical decision making or diagnosis including thresholds for treatment provision.

This thesis has demonstrated the possibility of creating norms for pain diagnostic subgroups, and has incorporated contextual demographic details of included populations. Future research could establish such norms using raw data should sufficient data become available, and percentile scores within each norm group could then be used to investigate the predictive validity of PCS scores in order to give further context for the interpretation of an individual's score.

Construct validity of pain catastrophising

Analysis of correlations between the PCS and self-report measures of other constructs, as well as other measures of pain catastrophising, were restricted in this thesis by the inconsistency of measures used across studies and the wide heterogeneity of correlations within constructs. This resulted in the impossibility of using multi-trait models (Campbell & Fiske, 1959) or a correlated uniqueness model (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003) to measure convergent and divergent validity of pain catastrophising and other constructs. However, the heterogeneity of correlations between the PCS and measures of other constructs is suggestive of divergent validity in that a stable relationship between the constructs has not been identified. Further research incorporating correlations between measures of pain-related constructs other than pain catastrophising would contribute to the context of construct validity within theories of pain cognitions.

Sufficient data was available to test the relationship between pain catastrophising as measured by the PCS and pain ratings as measured by the McGill Pain Questionnaire: Pain Rating Inventory (PRI). The high level of variance found between the scales that was due to artifacts including sample error (77%) surpassed the 75% threshold and can therefore be concluded to be artifactual (Borenstein, Hedges, Higgins, &Rothstein, 2009, p.349-350). Therefore, little can be concluded about the relationship between the constructs of pain catastrophising and pain intensity other than their measurement is subject to artifactual variance. Further analyses highlighted that variance was due largely to differences between study types, suggesting methodological error in research was a large factor.

Questions therefore remain regarding the uniqueness of pain catastrophising as a construct versus its overlap with other constructs. Cronbach and Meehl suggest that, even if there is high overlap with other constructs, a construct can still be a useful addition to a nomological network (the theoretical network of relationships between theories and constructs) if it 'reduce[s] the number of nomologicals required to predict the same observations' (1955, p. 290). For this reason, the predictive validity of the PCS could be a potential area for further investigation even if construct validity is not established. If the PCS is able to predict features of clinical interest such as psychological distress, risk of relapse or disability, or recovery rates, then it may be used in place of a battery of other test of constructs with which pain catastrophising might overlap. Some evidence of the predictive validity of the PCS is available within single studies (Sullivan et al., 1995), but as yet no meta-analytic methods have been applied.

Strengths and limitations of the thesis

Data collection

Studies were included in this thesis if data quality reached a pre-specified reporting threshold (i.e. a criterion was set that use of the PCS be reported in abstract of a study). This means that there is likely to be PCS data available in other studies in which PCS use was not reported in the abstract. Future research by a larger team might include

screening of papers for such studies; this would require full paper screening of over 3000 papers.

Missing data from studies, most notably reliability statistics and some demographic characteristics of participants including age and gender, resulted in lower power for some statistical analyses. However, the inclusion of these studies meant a greater amount of data was available overall.

Data on baseline PCS scores only was collected. Some studies included follow-up PCS scores or scores from before, during and after interventions. Further research could utilize these scores to explore changes in pain catastrophising following interventions.

The high proportion of 'healthy' participants in the included studies who were students limits the generalizability of the results to the general population of 'healthy' people without a pain diagnosis. This is not unique to this thesis and reflects biases and limitations of sampling practicalities in research.

A decision was made to exclude studies that made clear errors in obtaining scores from the PCS. For example, some studies described scoring the PCS items from 1-5 instead of from 0-4, and the PCS scores obtained accordingly demonstrated inflated marking. There is a counter argument for including all studies even with erroneous data, stating '[t]he solution to these methodological problems is to measure the deficiency and correct for it rather than discard the data' (Hunter & Schmidt, 2004, p.516). Although this line of thought was considered for the theory of data for this meta-analysis, it would be difficult to correct for studies' erroneous marking without the full set of raw data to also correct for missing scores and to score the PCS subscales. For this reason, it was decided to exclude these studies. The decision to exclude versions of the PCS that contained a different number of items – for example, the Hebrew version which contains 12 instead of 13 items - was also relevant to the aim of evaluating the construct validity of the scale. A version with a different number of items is arguably measuring something different, as it does not contain the full information needed to measure pain catastrophising as set out by Sullivan et al. (1995) and concluded by confirmatory factor analysis (Osman et al., 1997).

The principle of measuring rather than selecting against methodological deficiency was however upheld in the decision to include all studies regardless of risk of bias. The results of sensitivity analysis alluded to bias that influenced the PCS scores in studies; however, steps were taken to counter this bias by weighting scores using a random effects model in the meta-analysis.

The decision to include other language versions of the PCS could potentially have introduced biases and inaccuracies owing to different psychometric properties between these versions. A study by Bardhoshi, Duncan and Erford (2016) only used the English version of Beck Anxiety Index (Beck et al., 1961) in their psychometric analysis because of the failure of other language versions to conform to best practice translation procedures as set out by the American Educational Research Association, American Psychological Association, & National Council on Measurement in Education (1999, Standard 9.7). Challenges in translating outcome measures were acknowledged, and steps were taken in this thesis to test for biases and differences between the English version and other language versions by including language as a variable in multivariate meta-regression analyses. The decision to include other language versions was based on the widespread international use of the PCS, highlighting the need for further verification of the translated versions of the questionnaire. Furthermore, four of the six studies reporting test-retest statistics were psychometric studies of foreign language versions of the PCS, which therefore provided essential data to examine test-retest scores for the validity analysis of the scale. Again, a major strength of this meta-analysis was the large number of studies included.

Overall, the thesis demonstrates a comprehensive attempt to identify relevant papers and a systematic method of discussing and deciding on inclusion and exclusion of studies.

Inter-rater reliability

Limitations of the use of the kappa statistic (k) to determine inter-rater reliability include the argument that statistical significance of k is hard to define, and descriptions of the boundaries of scores (i.e. which k scores represent acceptable reliability) might

not be generalizable across all research (Viera & Garrett, 2005). For the purpose of this meta-analysis, the k statistic was deemed sufficient to conclude whether the screening strategy was reliable enough to continue with the content analysis. For more in-depth health studies, limitations of the k statistic would be more relevant and require further consideration (McHugh, 2012). It has been argued that Cohen's k has fewer and less serious limitations that competing methods of assessing inter-rater reliability (Hsu & Field, 2010), justifying its use in this meta-analysis.

Data preparation

The way data is prepared can have an impact on the data available for analysis. In this thesis, participants were categorized according to their pain diagnosis. This does not necessarily reflect clinical practice, as someone can be diagnosed with more than one pain condition. This is partially reflected in the finding of a high number of participants who did not fit into a pain diagnosis category, either because the study did not state diagnosis, or the participants who did have more than one diagnosis could not be validly placed in a single category. Different studies used different ways of categorizing pain or describing pain diagnoses, meaning that data were matched to 'best fit' for this meta-analysis.

Risk of bias assessment

The risk of bias screening was completed by one author (CW). Optimally, a second author would duplicate the screening and results would be compared.

Methodology

Established protocols for systematic review and meta-analysis were followed (see the PRISMA statement by Moher et al., 2009), with considerations and explanations offered for any diversion from these guidelines.

A methodological strength of this thesis is the use of meta-analytic methods (specifically Hedges and Olkin's 1985 method) to correct for measurement artifacts within included studies by weighting scores to obtain more accurate estimated effect sizes.

Advice was sought and followed from a statistician in the School of Medicine at the University of Leeds and from an applied psychologist in the School of Psychology with expertise in the application of meta-analysis to clinical populations. This advice helped to ensure that the methods used in this thesis were appropriate and applicable to research and clinical psychology.

Use of regression analysis

Samples used in the regression analysis were not fully independent in that, frequently, more than one participant group was included from a study. This increased the number of groups available to analyse, but the results should be treated with caution due to this non-independence of samples.

Developing norms

This thesis used a much larger dataset than has been used before to establish norms for PCS scores. Furthermore, norms were created for specific pain conditions, which makes the scores more relevant to individuals within clinical practice. A limitation of the norms is that they are established from summary data rather than raw PCS scores, and it is not recommended that they are used in clinical decision making. Further research using raw scores to construct norms alongside multiple regression would facilitate a determination of the patient variables that predict PCS scores (van Breukalen & Vlaeyan, 2005).

Assessing construct validity

Although the consolidation of Cronbach's Alpha scores for reliability within studies provides some information about the construct validity of the PCS, the correlations available in the dataset between the PCS and other measures of pain catastrophising as well as measures of other constructs were insufficient and too heterogeneous to fully establish the convergent and divergent validity of pain catastrophising.

Relevance of the findings to research

The findings of this thesis add further evidence for the use of psychometric meta-analysis to establish and refine the properties of self-report measures used in clinical

psychology. Further psychometric meta-analysis is recommended on the PCS to establish norms using raw data from multiple studies. However, it is recognized that obtaining raw data from authors can be difficult and would likely result in fewer studies included in the meta-analysis (Stewart & Tierney, 2002). Conducting such research would therefore involve a pay-off between obtaining raw data that can be more helpful in establishing norms, versus the norms being based on a smaller sample of participants.

Should the data become available, research into the convergent and divergent validity of the PCS with other measures of pain catastrophising and measures of other constructs is recommended. This would help to establish the construct validity of the PCS.

Missing data was prevalent in several categories of data collection in this thesis, particularly in the reporting of reliability statistics such as Cronbach's alpha, and in demographic characteristics of participants such as age and gender. A recommendation is made to all researchers to adhere to high quality standards of reporting in order for data to be useful for further research.

This thesis answered research questions regarding construct validity of pain catastrophising as measured by the PCS, and accuracy of the established psychometric properties of the PCS. In the process of meeting these aims, further questions were highlighted. Firstly, this thesis studied only the adult version of the PCS. Although no significant effect of age was found on PCS scores, the existence of a child version of the PCS suggests that a developmental change in pain catastrophising could be expected through the lifespan. Further research into the measurement of pain catastrophising in children and in adults, and implications for the theory of pain catastrophising, are recommended. Similarly, other versions of the PCS include those for parents (Goubert, Eccleston, Vervoort, Jordan, & Crombez, 2006) and spouses (Cano, Leonard, & Franz, 2005). The existence of these questionnaires suggests the possibility of catastrophising about others' pain as well as one's own pain. This introduces new aspects of construct validity that require testing: for example, the links between pain catastrophising and personal identity need to be extended to perception of others' pain and identity. Meta-analytic investigation into psychometric properties of these different versions, and how they relate to each other, as well as to constructs and theories of pain catastrophising,

could help to resolve questions around the purpose of catastrophising (such as social and care-gaining effects) and related factors including others' responses.

Changes from baseline PCS scores following treatment such as surgery or psychological therapy were not considered in the scope of this thesis. Meta-analysis of PCS scores could help to establish the efficacy of treatments for pain catastrophising, and to resolve whether treating the pain or treating pain catastrophising have a greater effect.

Finally, the methods used in this meta-analysis could be applied to any self-report measure used in clinical psychology or other fields. The use of meta-analysis to establish a stronger evidence base for the psychometric properties of questionnaires is encouraged following this thesis. This would help to create greater theoretical justification for the use of self-report measures, as well as highlight those that do not meet standards of reliability and validity. Such research could help to slow the trend of ever-increasing numbers of concepts and measures in the field of clinical psychology.

Relevance of the findings to clinical practice

Studies in this meta-analysis highlighted that the PCS is used worldwide for research and clinical practice. Current normative values and clinical cut-off scores are based on a sample of 851 injured workers, 75% of whom had a soft tissue back injury (Sullivan et al., 1995, p 6). This meta-analysis demonstrated that percentile scores as used to establish this clinical-cut-off vary between clinical groups based on pain diagnoses. This brings into question the concept of a clinically relevant score: should the clinical cut-off for pain catastrophising be based on percentiles across pain diagnoses, or is it more pertinent to establish a cut-off using comparisons of a person's score to other who have a similar pain condition? Either of these options is likely to be preferable to using the current clinical cut-off based on one study of a sample of injured workers alone. Further research is necessary to establish percentile scores either across or within pain conditions, but using raw scores rather than the summary data available in this meta-analysis.

Studies in this meta-analysis also demonstrated the wide range of measures used in psychology research and clinical practice. Given the tendency for measures to gain widespread use without their psychometric characteristics confirmed through large sampling methods (Morley, in press), this raises concerns about their validity and reliability. The finding that multiple different questionnaires were used to measure the same concept raises questions about the need for so many different measures. Furthermore, the wide range of correlations between measures of the same construct and the PCS suggests disparity between constructs measured or measurement error in the questionnaires. This, again, leads to a conclusion that caution is necessary in interpreting the results of measures used in clinical psychology, particularly those that have not been subjected to psychometric meta-analysis to confirm validity and reliability.

Conclusion

This is the first psychometric meta-analysis of the PCS, and the first investigation of the PCS on such a large scale. The use of meta-analysis offered an opportunity to consider the relevance of the use of the PCS in research and clinical practice since its development, and to enhance understanding of the construct of pain catastrophising that it measures. Meta-analytic methods in this thesis confirmed the reliability of the scale and refined psychometric and normative properties. Construct validity of the PCS was upheld within the limitations of the data available, with some level of divergent validity with other pain-related psychological constructs evident. However, further research is necessary to fully explore the convergent and divergent validity of pain catastrophising and other constructs. The PCS is concluded to be a reliable measure of pain catastrophising. Caution is urged in the clinical interpretation of scores due to differences in scores between people with different pain diagnoses. This thesis has demonstrated that it is possible to use meta-analytic methods to establish more accurate psychometric properties of psychological measures.

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Appendix A

The Pain Catastrophising Scale

Pain Catastrophizing Scale

Sullivan MJL, Bishop S, Pivik J. (1995)

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

Everyone experiences painful situations at some point in their lives. Such experiences may include headaches, tooth pain, joint or muscle pain. People are often exposed to situations that may cause pain such as illness, injury, dental procedures or surgery.

Instructions:
We are interested in the types of thoughts and feelings that you have when you are in pain. Listed below are thirteen statements describing different thoughts and feelings that may be associated with pain. Using the following scale, please indicate the degree to which you have these thoughts and feelings when you are experiencing pain.

RATING	0	1	2	3	4
MEANING	Not at all	To a slight degree	To a moderate degree	To a great degree	All the time

When I'm in pain …

Number	Statement	Rating
1	I worry all the time about whether the pain will end.	
2	I feel I can't go on.	
3	It's terrible and I think it's never going to get any better	
4	It's awful and I feel that it overwhelms me.	
5	I feel I can't stand it anymore	
6	I become afraid that the pain will get worse.	
7	I keep thinking of other painful events	
8	I anxiously want the pain to go away	
9	I can't seem to keep it our of my mind	
10	I keep thinking about how much it hurts.	
11	I keep thinking about how badly I want the pain to stop	
12	There's nothing I can do to reduce the intensity of the pain	
13	I wonder whether something serious may happen.	

Source: **Sullivan** MJL, **Bishop** S, **Pivik** J. The **pain catastrophizing scale**: development and validation. *Psychol Assess*, **1995**, 7: 524-532

Appendix B

Table of characteristics of studies included in the review and meta-analysis

Study ID	Author	Year of publication	Study type	Language	Participant group	Sample size	Mean age	Sd age	M:F participants	Mean PCS score	Sd PCS score
3	Barke	2015	Psychometric	German	Chronic back pain	182	51	10.5	54:128	19.7	12.1
6	Iwaki	2012	Cross	Japanese	Chronic pain	160	51	16.4	48:112	33.9	10.2
7	Karstens	2015	Psychometric	German	Lower back pain	228	42	11	120:128	16.7	10.5
8	Kikuchi	2015	Cross	Japanese	Whiplash neck injury pain and/or low back pain	956	45	10.4	679:277	24	11.8
9	Kim	2013	Psychometric	Korean	Degenerative spinal disease	72	66	8.1	27:45	24.1	12.2
10	Kjogx	2014	Cross	Danish	Chronic headache	57	49	15.1	57:0	16.9	10.4
10	Kjogx	2014	Cross	Danish	Chronic headache	161	45	15.2	0:161	22.5	12
10	Kjogx	2014	Cross	Danish	Healthy participants	118	22	7.2	118:0	10.3	6.7
10	Kjogx	2014	Cross	Danish	Healthy participants	129	22	5.2	0:129	12.3	8.7
11	Koo	2015	Psychometric	Korean	Chronic pain	64	41	14.5	23:41	18.8	11.9
12	Kraljevic	2012	Cross	Croatian	Chronic pain	100	55	10	36:64	31	12.6
12	Kraljevic	2012	Cross	Croatian	Healthy participants (adult children)	100	30	10	50:50	21.8	12.2
12	Kraljevic	2012	Cross	Croatian	Healthy participants (spouse)	85	60	10	51:34	25.6	13.4
16	Lim	2006	Psychometric	Chinese	Chronic pain	120	/	/	50:70	31.9	11.1
17	Lopes	2015	Psychometric	Brazilian Portuguese	Acute low back pain	131	67	7.1	10:121	29.2	13.1
18	Man	2007	Case	Chinese	Chronic pain	45	/	/	15:30	33.7	12.1
19	Maric	2011	Cross	Croatian	Healthy participants	53	24	1.8	10:43	16.8	9.9

19	Maric	2011	Cross	Croatian	6th yr medical students Healthy participants 1st yr medical students Healthy participants	137		19	1.7	47:90	19.2	7.9
19	Maric	2011	Cross	Croatian	1st yr economics students Healthy participants	245		19	1.7	86:159	19.7	9.1
19	Maric	2011	Cross	Croatian	5th yr economics students	86		23	1.7	22:64	19.8	10.1
20	Matsudaira	2014	Psychometric	Japanese	Low back pain	1786		49	/	900:886	24.6	10.9
21	Matsuoka	2010	Case	Japanese	Burning mouth syndrome	46		60	9.6	2:44	28.2	9.7
23	Meyer	2008	Psychometric	German	Low back pain	111		49	16	36:75	17.6	10.5
25	Mohd Din	2015	Psychometric	Malay	Healthy participants military	303		21	1.8	258:45	19.2	10.2
29	Morris	2012	Psychometric	Africaans	Fibromyalgia, Africaans speaker	41	/		/	/	37	11.4
29	Morris	2012	Psychometric	English South African	Fibromyalgia, English speaker	33	/		/	/	38.2	11.5
29	Morris	2012	Psychometric	Xhosa	Fibromyalgia, Xhosa speaker	19	/		/	/	34.2	8.5
30	Ning	2008	Psychometric	Cantonese	Chronic pain	224		42	10.3	120:104	36.3	10.9
35	Penhoat	2014	Cross	French	Rheumatoid arthritis	86		59	13.7	27:59	17	13.6
35	Penhoat	2014	Cross	French	Spondyloarthritis	54		43	10.1	37:17	20.8	12.1
37	Rodero	2010	Psychometric	Spanish	Fibromyalgia	205		50	9.7	19:186	32.4	12.8
38	Rodero	2012	Psychometric	Spanish	Fibromyalgia	250		52	8.5	11:239	24.3	13.6
40	Roelofs	2003	Psychometric	Dutch	Fibromyalgia	401		48	10.1	22:379	20.3	11.5
41	Roelofs	2002	Psychometric	Spanish	Healthy participants students	271		19	1.4	54:226	14.3	7.9

42	Rogulj	2014	Cross	Croatian	Burning mouth syndrome	30		66	9.2	5:25	28.4	15
43	Sehn	2012	Psychometric	Brazilian Portuguese	Chronic musculoskeletal pain	384		50	17.1	67:317	30.6	11.7
44	Severijns	2002	Cross	Dutch	Hip/knee pain	582	/		/	/	12.1	10.4
44	Severijns	2002	Cross	Dutch	Low back pain	754	/		/	/	12.2	10.4
44	Severijns	2002	Cross	Dutch	Neck/shoulder/high back pain	880	/		/	/	12.3	10.3
44	Severijns	2002	Cross	Dutch	Elbow/wrist/hand pain	480	/		/	/	13	10.8
44	Severijns	2002	Cross	Dutch	Ankle/foot pain	284	/		/	/	13.5	11
44	Severijns	2002	Cross	Dutch	Healthy participants, no pain	1164	/		/	/	8.2	8
46	Suren	2014	Cross	Turkish	Preoperative patients	165		39	13.9	91:74	16.1	11.5
48	Van Damme	2002	Psychometric	Dutch	Low back pain	162		42	11.6	63:99	22	9.3
48	Van Damme	2002	Psychometric	Dutch	Fibromyalgia	100		45	9.1	20:80	24.8	12.2
48	Van Damme	2002	Psychometric	Dutch	Healthy participants students	550		19	1.4	147:403	16.6	7.8
49	Volz	2013	Series	Brazilian Portuguese	Chronic myofascial pain syndrome	24		48	12.6	0:24	34.2	9.2
50	Wong	2015	Series	Chinese	Chronic pain	226		45	9.2	77:149	26.7	14.7
51	Wong	2011	Psychometric	Chinese	Chronic musculoskeletal pain	208		41	11.3	95:113	29	14.3
54	Yap	2008	Psychometric	Chinese	Chronic nonmalignant pain	130	/		/	54:76	29.1	5.5
56	Park	2015	Cross	Korean	Temporomandibular disorder	155		39	15.2	44:111	17.3	12.6
65	Adachi	2014	Cross-sectional study	Japanese	Chronic pain	176		64	15.1	80:96	26.5	12.2
66	Aerts	2015	Cohort study	English	Secondary provoked vestibulodynia	175		28	5.5	0:175	26.7	10.7

66	Aerts	2015	Cohort study	English	Primary provoked vestibulodynia	94	26	5.5	0:94	27.6	10
67	Akhter	2014	Other	English	Healthy participants	28	35	9.5	20:8	15.4	11.4
69	Alappattu	2015	Cross	English	Pelvic pain	14	40	/	0:14	23.1	12.4
69	Alappattu	2015	Cross	English	Healthy participants	28	30	/	0:28	9.2	9.7
70	Albert	2015	Cohort study	French	Musculoskeletal disorder	43	41	12	20:23	19	12
71	Al-Kaisy	2015	Retrospective cohort stud	English	Chronic neuropathic pain of upper or lower limbs	11	46	12	5:6	33	11
75	Archer	2015	Cohort	English	Lower extremity trauma	134	45	15	70:64	14	13
77	Baranoff	2015	Cohort	English	Anterior cruciate ligament reconstruction	44	27	9.4	27:17	11.3	9.8
78	Barnhoorn	2015	RCT secondary data analysis	Dutch	Complex Regional Pain Syndrome type 1	35	43	16.9	6:29	22.8	11.7
78	Barnhoorn	2015	RCT secondary data analysis	Dutch	Complex Regional Pain Syndrome type 1	21	46	16.5	5:16	24.9	14.8
81	Beck	2014	Series	English	Orthodontic elastomeric separators	20	24	3.4	9:11	14.6	7.6
86	Beneciuk	2013	Series	English	Low back pain	146	41	13.5	57:89	16.8	12.1
87	Beneciuk	2012	Secondary analysis	English	Acute and subacute low back pain	108	37	14.5	39:69	16.3	11.2
90	Bhaskaracharya	2015	Cross	English	Pain-free participants with a history of chronic trigeminal neuropathic pain	12	64	9.5	0:12	15.9	13.3
90	Bhaskaracharya	2015	Cross	English	Healthy participants control group	15	62	6.9	4:11	7.1	11.7

91	Billis	2013	Cross	English	Non-specific low back pain	106	36	15.9	43:63	19.4	7.9
92	Block	2008	Cross	English	Chronic pain	43	44	12.7	17:26	23.9	11.8
94	Bond	2015	Series	English	Migraine and obesity	105	38	8	0:105	22.7	10.8
96	Borg	2012	Cross	Dutch	Dyspareunia	33	27	6.8	0:33	15.3	7.3
96	Borg	2012	Cross	Dutch	Vaginismus	35	28	5.8	0:35	22	9.3
96	Borg	2012	Cross	Dutch	Healthy participants without sexual complaints	54	27	6.7	0:54	17.4	9.1
98	Bostick	2013	Series	English	Whiplash associated disorder	72	39	14	15:57	24.7	9.4
99	Bot	2014	Psychometric	English	Upper extremity diagnoses	164	51	15	75:89	5.3	6.9
101	Bot	2013	Series	English	Post patients hand surgery nonresponders to later survey	69	48	16	37:32	3.2	4.9
101	Bot	2013	Series	English	Post patients hand surgery responders to later survey	35	56	17	10:25	5.6	7.2
102	Bot	2014	Cross	English	Painful conditions of the upper extremity	130	52	16	62:68	8.7	9.4
103	Bot	2013	Cohort	English	Arm, shoulder and hand disability	1204	53	16	511:693	6.8	8.4
108	Brandini	2011	Case	English	Temperomandibular disorder	15	31	10.7	0:15	12.7	10.6
108	Brandini	2011	Case	English	Healthy participants	14	29	5	0:14	11	8.4
114	Bryson	2014	Cross	English	Chronic pain and insomnia	111	44	10.9	35:76	30.6	14.7
116	Buitenhuis	2008	Series	English	Postwhiplash syndrome	140	36	12	45:95	12.9	11.3
119	Calley	2010	Cross	English	Low back pain	80	47	11.5	34:46	13.9	10.1

120	Campbell	2010	Case	English	Temperomandibular joint disorder	48		34	12	7:41	14.3	9.2
120	Campbell	2010	Case	English	Arthritis	43		55	9.7	16:27	15.4	12
120	Campbell	2010	Case	English	Healthy participants	84		34	14.6	51:33	9.5	9
123	Carroll	2011	Case	English	Palliative care patients on opioid treatment	20		58	10	9:11	19.8	13.3
125	Carvalho	2014	Series	English	Labour and successful vaginal delivery	39		34	5	0:39	16	9
128	Casey	2015	Cohort	English	Whiplash injury	246		43	14.6	54:192	16.1	13.2
130	Cebolla	2013	Psychometric	Spanish	Fibromyalgia	251		52	8.4	10:241	24.3	13.6
135	Chatkoff	2015	Cross	English	Muskuloskeletal pain, adaptive copers	26	/		/	/	20.3	13.9
135	Chatkoff	2015	Cross	English	Muskuloskeletal pain, dysfunctional	15	/		/	/	27.8	12.8
135	Chatkoff	2015	Cross	English	Muskuloskeletal pain, dysfunctional	28	/		/	/	32.5	10.1
138	Chibnall	2005	Psychometric	English	Low back injury, compensation claimants	1475	/		/	919:556	25.4	12.1
140	Choobmasjedi	2012	Cross	Arabic	Healthy volunteers pregnant	300		28	5.9	0:300	29.3	11.8
142	Chung	2012	Series	Chinese	Major depressive disorder	91		48	9.5	18:73	23.7	13.1
143	Chung	2015	Other	Chinese	Major depressive disorder	137		50	9.6	28:109	24.6	11.3
149	Cosic	2013	Cohort	Croatian	Parous	69		30	/	0:69	16.1	13.2
149	Cosic	2013	Cohort	Croatian	Nulliparous	80		24	/	0:80	23.9	12.6
151	Curran	2010	Series	English	Provoked vestibuladynia	8		30	10.6	0:8	24.8	7.9
153	Darchuk	2010	Series	English	Non-cancer pain,	78		67	5.6	28:50	25.6	13.7

					geriatric patients, older							
153	Darchuk	2010	Series	English	Non-cancer pain, geriatric patients, middle aged	230		48	5.3	43:187	26.2	12.1
153	Darchuk	2010	Series	English	Non-cancer pain, geriatric patients, younger	141		30	6.2	25:116	27.3	12.6
154	Darnall	2012	Cross	English	Chronic pain, incarcerated women	159		39	11.5	0:159	27.1	11.8
155	Darnall	2014	Series	English	Chronic pain outpatients	57		50	12.2	16:41	26.1	10.8
159	Davidson	2008	Psychometric	English	Chronic pain	126		50	14.2	40:86	22.4	13.2
161	Davis	2015	Series	English	Provoked vestibulodynia	222		31	10.9	0:222	28.2	10.8
165	de Boer	2014	Cross	Dutch	Chronic pain, outpatients	89		51	15.5	34:55	22.4	13
172	Demoulin	2010	Psychometric	Dutch	Chronic low back pain	99		42	9.4	60:39	22.2	10.3
173	D'Eon	2004	Psychometric	English	Healthy participants, students, men	229		21	3.7	229:0	20.6	9.6
173	D'Eon	2004	Psychometric	English	Healthy participants, students, women	276		20	4.1	0:276	26.4	9.4
176	Dimitriadis	2014	Psychometric	Greek	Chronic neck pain	45		36	14.5	13:32	21.4	12
179	Dixon	2004	Other experimental	English	Healthy participants, college students, men	91	/		/	91:0	16.6	7.9
179	Dixon	2004	Other experimental	English	Healthy participants, college students, women	112	/		/	0:112	19.2	9.7
185	Durosaro	2008	Series	English	Erythromelalgia	8		43	16.8	1:7	29.9	6.8
191	Fabian	2011	Cross	English	Healthy participants, college students, men	24	/		/	24:0	13.8	7.8
191	Fabian	2011	Cross	English	Healthy participants,	62	/		/	24:38	15.9	8.2

					college students							
193	Feldman	2015	Cross	English	Patients undergoing total knee arthroplasty	316	66	8.7	130:186	12	10.7	
195	Fernandes	2002	Psychometric	Norwegian	Non-specific low back pain	90	48	11.7	38:52	13.6	9.2	
197	Fitzcharles	2014	Cross	English	Fibromyalgia	246	48	10.4	22:224	29.3	12.2	
199	Flink	2009	Series	Swedish	Prepartum	82	/	/	0:82	19.6	9.5	
200	Forsythe	2008	Series	English	Preoperative patients before total knee arthroplasty	55	69	8.4	20:35	9.8	8.7	
201	Fritz	2015	Rct	English	Recent-onset low back pain	112	37	10.2	59:53	13.8	10.1	
201	Fritz	2015	Rct	English	Recent-onset low back pain	108	38	10.4	46:62	13.9	11	
202	Gagnon	2013	Series	English	Chronic pain	101	44	8.2	64:37	28	15	
203	Gandhi	2010	Psychometric	English	Hip osteoarthritis	100	63	10.6	50:50	16.6	13.7	
203	Gandhi	2010	Psychometric	English	Knee osteoarthritis	100	67	8.4	31:69	17.3	13.3	
205	Garcia-Campayo	2010	Psychometric	Spanish	Fibromyalgia	250	45	7.2	21:229	30.8	11.7	
206	Herbst	2010	Series	English	Adiposis dolorosa	10	48	3.6	4:6	28.2	3.5	
207	Gautier	2011	Cross	Other	Chronic pain, men	26	41	8	26:0	23.7	9.4	
207	Gautier	2011	Cross	Other	Chronic pain, women	24	39	10.6	0:24	27.1	13.1	
209	George	2011	Psychometric	English	Low back pain	80	47	11.5	34:46	14.1	10.1	
212	Geva	2013	Case	English	Healthy participants triathletes	19	40	12.1	11:8	16.5	9	
212	Geva	2013	Case	English	Healthy participants controls	17	37	11.1	7:10	20.8	12	
214	Gilliam	2010	Cross	English	Healthy participants	97	25	2.8	41:56	19.5	8.8	
215	Goodin	2011	Other	English	Healthy participants, college students, Caucasian American	86	/	/	/	13.2	8.6	

215	Goodin	2011	Other	English	Healthy participants, college students, African American	28	/	/	/		15.4	11.5
215	Goodin	2011	Other	English	Healthy participants, college students, Asian American	35	/	/	/		15.9	9.9
219	Grotle	2012	Psychometric	Norwegian	Pelvic girdle pain in pregnancy and after delivery	87		34	5.3	0:87	13.5	8.7
223	Hayashi	2015	Series	Japanese	Neck-shoulder pain	87		51	16.4	35:52	32.1	10.6
223	Hayashi	2015	Series	Japanese	Headache	62		51	18.3	14:48	33.7	10.3
223	Hayashi	2015	Series	Japanese	Low back/lower limb pain	142		57	15	58:84	33.7	10.1
224	Hegarty	2014	Cross	English	Post-enucleation, persistent pain	8		61	18.1	6:2	3.6	6.8
224	Hegarty	2014	Cross	English	Post-enucleation, no pain	9		61	18.2	3:6	6.8	15.9
228	Hiebert	2012	Series	English	Low back pain, active duty US navy personnel	253		32	7.9	188:65	11.1	9.9
229	Hirakawa	2014	Series	Japanese	Patients three weeks post surgery	90		76	6.3	20:70	13	9.3
230	Hirsch	2008	Psychometric	English	Healthy participants, undergraduate students	100		21	1.7	44:66	18.6	9.2
235	Hooten	2009	Cohort	English	Chronic pain, never smoked, male	134		47	13.6	134:0	23.1	12.3
235	Hooten	2009	Cohort	English	Chronic pain, never smoked, female	500		46	4.8	0:500	24.8	13
235	Hooten	2009	Cohort	English	Chronic pain, former smoker, female	203		50	12.9	0:203	26	11.9
235	Hooten	2009	Cohort	English	Chronic pain, former smoker, male	91		54	13.5	91:0	26.2	11.1

235	Hooten	2009	Cohort	English	Chronic pain, smoker, female	225		43	10.9	0:225	27.6	13.2
235	Hooten	2009	Cohort	English	Chronic pain, smoker, male	88		42	12	88:0	31.5	11
238	Horsham	2013	Cross	English	Experienced trauma but no PTSD	91	/	/	/		13.6	7.8
238	Horsham	2013	Cross	English	Control (no experience of trauma, no PTSD)	71	/	/	/		8.6	4.3
238	Horsham	2013	Cross	English	Ptsd	87	/	/	/		25.3	8
241	Kadimpati	2015	Cross	English	Chronic pain	595		47	13.7	173:422	26.7	11.2
242	Kao	2012	Cross	Other	Postmenapausal dyspareunia sufferers	182		57	5.4	0:182	16.1	13.2
244	Karayannis	2013	Cross	English	Low back pain	19		43	13.2	6:14	14.4	8.2
246	Karsdorp	2009	Cross	Dutch	Fibromyalgia	409		48	10.2	21:388	20.3	11.4
252	Khan	2012	Series	English	Cardiac surgery, preoperative	64		66	11.1	54:10	11.7	11.1
253	Kim	2015	Psychometric	Korean	Degenerative lumbar spinal stenosis, men	35		64	12.8	35:0	19.9	13.3
253	Kim	2015	Psychometric	Korean	Degenerative lumbar spinal stenosis, women	60		66	9.6	0:60	27.9	11.5
254	Kim	2014	Cross	Korean	Lumbar spinal stenosis	155		65	12.4	57:98	24.9	12.8
256	Kleiman	2011	Psychometric	English	Patients scheduled for major surgery	444		46	10.2	174:270	16.5	10.5
257	Koele	2014	Series	Dutch	Chronic widespread musculoskeletal pain	165		44	12.9	22:143	17.5	9.4
260	Kristjansdottir	2013	Rct	Norwegian	Chronic widespread pain	66		44	11.2	0:66	20.8	9.5
260	Kristjansdottir	2013	Rct	Norwegian	Chronic widespread pain	69		45	11.1	0:69	21.2	10.3
263	La Touche	2014	Cross	Spanish	Chronic craniofacial	192		46	13.1	60:132	23.9	8.9

					pain						
264	Lame	2008	Psychometric	Dutch	Chronic pain	50	55	13.1	20:30	30.2	11.7
265	Lariviere	2010	Cohort	English	Chronic low back pain, women	13	35	9	0:13	15	13
265	Lariviere	2010	Cohort	English	Chronic low back pain, men	14	43	10	14:0	26	10
268	Lee	2008	Psychometric	English	Healthy participants	189	27	8	99:90	11.4	7.4
269	Lemieux	2013	Cross	French	Dyspareunia	179	31	10	0:179	28.6	9.7
270	Leonard	2013	Cross	English	Chronic musculoskeletal pain	57	56	15.1	16:41	25.7	14.2
271	Lin	2013	Other	Chinese	Healthy participants	15	26	11.2	6:9	19.2	8.1
272	Lindenhovius	2008	Rct	English	Lateral elbow pain, placedo, lidocaine only	30	51	10	12:18	20.8	8.5
272	Lindenhovius	2008	Rct	English	Lateral elbow pain, dexamethasone	27	50	8	10:17	21.8	10.5
274	London	2014	Cohort	English	Atraumatic hand or wrist condition	256	56	12.6	75:181	11.8	8.9
275	Louw	2015	Series	English	Patients scheduled for lumbar surgery	10	47	16.2	3:7	25.4	13.5
280	Lukkahatai	2013	Cross	English	Fibromyalgia patients with fatigue	9	41	7.3	0:9	17	9.8
282	Theunissen	2014	Psychometric	Dutch	Preoperative hysterectomy	192	46	7.8	0:192	13.1	8.5
282	Theunissen	2014	Psychometric	Dutch	Patients undergoing day surgery, preoperative	75	53	15.3	31:44	14	8.8
282	Theunissen	2014	Psychometric	Dutch	Mixed inpatient	1490	56	15.5	702:788	16.5	12.7
283	Martel	2013	Series	English	Chronic pain, women	35	50	8.9	0:35	24.3	13.6
283	Martel	2013	Series	English	Chronic pain, men	20	49	10.5	20:0	24.5	10.4
284	Martin	2010	Cross	English	Chronic pain patients pre-surgery	208	47	9.7	83:124	19.3	7.9

285	Martinez	2012	Cross	Spanish	Healthy participants	200	40	11.3	0:200	13.7	10
288	Masselin-Dubois	2013	Cohort	French	Breast cancer patients pre-surgery	100	55	12.1	0:100	14.6	11.4
288	Masselin-Dubois	2013	Cohort	French	Total knee arthroplasty patients pre-surgery	89	69	8.9	35:65	19.4	11.2
290	McLoughlin	2011	Cross	English	Women with fibromyalgia	39	43	12.1	0:39	13.9	7.7
290	McLoughlin	2011	Cross	English	Women healthy controls	40	41	9.1	0:40	8.5	7
291	McWilliams	2007	Psychometric	English	Healthy participants, university students	278	20	4	145:136	15.7	9
292	McWilliams	2015	Psychometric	English	Chronic pain	201	47	10.3	74:127	25.8	12
293	Meeus	2010	Rct	Dutch	Chronic fatigue syndrome and chronic widespread pain, experimental group	24	38	10.6	2:22	18.2	6.9
293	Meeus	2010	Rct	Dutch	Chronic fatigue syndrome and chronic widespread pain, control group	24	42	10.2	6:18	21.8	8.9
294	Meyer	2009	Cross	German	Chronic low back pain	78	50	17	26:52	19.2	10.3
295	Michael	2004	Series	English	Chronic pain	86	42	10.4	46:40	27	13.3
298	Monticone	2014	Rct	Italian	Chronic low back pain, control group	10	57	14.4	6:4	23	4
298	Monticone	2014	Rct	Italian	Chronic low back pain, experimental group	10	59	16.4	3:7	25	6
300	Monticone	2014	Rct	Italian	Spondylolisthesis and/or lumbar spinal	65	59	11.8	21:44	24.8	9.3

					stenosis, experimental group						
300	Monticone	2014	Rct	Italian	Spondylolisthesis and/or lumbar spinal stenosis, control group	65	56	14.2	30:35	27	8.7
301	Monticone	2015	Psychometric	Italian	Chronic neck pain	118	48	15.9	40:78	18.5	9
302	Moore	2013	Cross	English	Healthy participants, male	70	23	6.6	70:0	18	8.6
302	Moore	2013	Cross	English	Healthy participants, female	119	24	5.9	0:119	20.5	8.3
303	Moseley	2004	Series	English	Chronic low back pain, group 2	46	35	7	16:30	16	5
303	Moseley	2004	Series	English	Chronic low back pain, group 1	75	36	6	38:37	16	6
304	Moseley	2004	Rct	English	Chronic low back pain, experimental group	31	42	10	13:18	19	6
304	Moseley	2004	Rct	English	Chronic low back pain, control group	27	45	6	12:15	20	6
307	Moustafa	2015	Rct	English	Fibromyalgia and C1-2 joint disfunction	60	51	7	33:27	42.5	3
307	Moustafa	2015	Rct	English	Fibromyalgia and C1-2 joint disfunction	60	54	8	35:25	43.8	3.6
308	Munoz	2005	Cross	Other	Chronic pain	149	59	15	42:107	20.9	16.3
309	Nakamura	2014	Cross	Japanese	Chronic pain, receiving folk remedy	108	46	13.8	33:75	23.2	9.9
309	Nakamura	2014	Cross	Japanese	Chronic pain, seen at medical facility	213	55	14.8	84:129	26.5	10.3
310	Naugle	2014	Other	English	Healthy participants,	12	/	/	12:0	5.2	4.1

					young adults, men							
310	Naugle	2014	Other	English	Healthy participants, young adults, women	15	/		/		0:15	9.3	4.1
312	Nickel	2010	Case	English	Interstitial cystitis/painful bladder syndrome	207		50	15.1		0:207	21.3	12.6
312	Nickel	2010	Case	English	Healthy participants, control group	117		48	13.5		0:117	9.9	9.2
314	Nieto	2011	Cross	Spanish	Whiplash associated disorders	147		34	10.4		42:105	17.9	9.9
316	Nishigami	2015	Case	Japanese	Chronic low back pain, shrunken perceived body image	12		62	12.4		4:8	19.6	11.4
316	Nishigami	2015	Case	Japanese	Chronic low back pain, expanded perceived body image	12		57	16.7		4:8	21.4	6.5
316	Nishigami	2015	Case	Japanese	Chronic low back pain, normal perceived body image	18		65	11.2		8:10	21.6	7
317	Novak	2011	Cross	English	Upper-extremity nerve injury	158		41	16		105:53	16	15
318	Novak	2012	Cross	English	Brachial plexus nerve injury	61		40	17		41:20	15	14
319	Novak	2013	Psychometric	English	Upper extremity nerve injury	157		41	16		104:53	16	15
321	Ogunlana	2015	Cross	English	Nonspecific low back pain	275		52	13.4		110:165	24	10.4
325	Osman	2000	Psychometric	English	Pain outpatients, men	26		31	8.7		26:0	19.6	11.4
325	Osman	2000	Psychometric	English	Pain outpatients, women	34		33	10.7		0:34	24.3	8.8

325	Osman	2000	Psychometric	English	Healthy participants, men	85		36	10.8	85:0	11.1	8
325	Osman	2000	Psychometric	English	Healthy participants, women	130		35	12.2	0:130	15.7	10.9
326	Osman	1997	Psychometric	English	Healthy participants, students, study 2, men	59		20	2.5	59:0	10.9	7.8
326	Osman	1997	Psychometric	English	Healthy participants, students, study 3, women	86	/		/	0:86	11.7	8.4
326	Osman	1997	Psychometric	English	Healthy participants, students, study 1, men	93	/		/	93:0	11.9	8
326	Osman	1997	Psychometric	English	Healthy participants, students, study 1, women	195	/		/	0:195	14.6	9.6
326	Osman	1997	Psychometric	English	Healthy participants, students, study 2, women	161		20	3.7	0:161	15	9.5
326	Osman	1997	Psychometric	English	Healthy participants, students, study 3, men	86	/		/	86:0	18.4	9.6
327	Papaioannou	2009	Series	Greek	Degenerative disc disease	61		51	14.5	25:36	21.7	13.2
328	Parr	2012	Psychometric	English	Healthy participants	126		24	9.8	51:75	9.8	7.8
330	Pavlin	2005	Series	English	Anterior cruciate ligament injury	48		31	1.2	27:21	14.4	8.3
331	Pearson	2009	Cross	English	Whiplash-associated disorder	14		37	10.8	8:6	17	14.4
333	Philips	2014	Cross	English	HIV-associated sensory polyneuropathy	28		51	8.4	25:3	23.7	12.6
333	Philips	2014	Cross	English	HIV-positive but	38		48	8.9	32:6	14.1	11.8

					with no HIV-associated sensory polyneuropathy						
334	Pincus	2008	Psychometric	English	Non-cancer chronic pain	243	44	12	110:133	29.3	12.3
335	Plazier	2015	Series	Other	Fibromyalgia	11	42	8.3	0:11	20.6	8.8
337	Prugh	2012	Series	English	Throwing athletes with elbow injuries	3	21	2.5	3:0	5	7
338	Pukall	2007	Series	English	Vulvar vestibulitis syndrome	8	26	5.7	0:8	18.1	6.9
339	Raak	2006	Cross	Swedish	Whiplash associated disorder	17	51	11.3	1:16	19.9	7.8
339	Raak	2006	Cross	Swedish	Healthy participants	18	45	10.2	1:17	13	5.6
340	Radat	2013	Cohort	French	Chronic peripheral neuropathic pain	182	60	13.8	87:95	28	13
341	Reyahin	2014	Psychometric	English	Knee osteoarthritis	212	65	10.1	49:163	6.6	7
342	Riddle	2011	Nrct	English	Patients scheduled for knee arthroplasty, control group	45	61	9.9	12:33	25.8	11.1
342	Riddle	2011	Nrct	English	Patients scheduled for knee arthroplasty, experimental group	18	64	11.5	6:12	29.3	8.9
343	Ring	2005	Cross	English	Pain, single discrete pain complaint	56	55	15	22:34	14	11.3
343	Ring	2005	Cross	English	Pain, vague diffuse idiopathic arm pain	51	41	15	14:37	20.4	11.7
344	Rivest	2010	Cross	English	Whiplash associated disorder	37	35	12.2	16:21	16.4	14.2
346	Robles	2012	Series	English	Healthy participants	76	25	5.2	27:49	14.4	9.8
347	Rodero	2008	Series	Spanish	Fibromyalgia	8	/	/	1:7	25.3	10
348	Rodero	2010	Cross	Spanish	Fibromyalgia, under 2 years chronicity	46	47	9.8	/	30.9	14.3

348	Rodero	2010	Cross	Spanish	Fibromyalgia, 2-4 years chronicity	59	48	11	/		33.1	11.9
348	Rodero	2010	Cross	Spanish	Fibromyalgia, more than 4 years chronicity	223	50	10.5	/		33.1	11.6
349	Roh	2014	Series	Korean	Patients post-surgery distal radius fractures	121	53	14		54:67	22	9
350	Roh	2015	Series	Korean	Patients with surgically treated hand fractures	93	45	12		55:48	23	8
351	Rosenberg	2015	Series	English	Chronic pain of trunk and/or limbs	386	56	14.5		156:230	30.2	12.1
353	Roth	2007	Series	English	Patients pre-surgery, total knee arthroplasty	63	70	8.8		29:34	7.1	7.3
355	Ruiz-Parraga	2014	Cross	Spanish	Chronic musculoskeletal pain, non-trauma-exposed	117	43	11.7		36:81	20.5	6.5
355	Ruiz-Parraga	2014	Cross	Spanish	Chronic musculoskeletal pain, trauma-exposed without post traumatic stress symptoms	119	44	11.2		36:83	21	6.9
355	Ruiz-Parraga	2014	Cross	Spanish	Chronic musculoskeletal pain, trauma-exposed with post traumatic stress symtoms	110	47	12.5		30:80	31.9	10.3
356	Ruschewe yh	2011	Cross	German	Healthy participants, younger group	88	27	4.8		29:59	15.5	8.8
356	Ruschewe yh	2011	Cross	German	Healthy participants, older group	46	60	5.2		20:26	20.2	11.2

357	Sanchez	2011	Cross	Spanish	Fibromyalgia	74	47	8.1	4:70	25.4	11.8
358	Sansone	2014	Cross	English	Primary care patients	239	46	15	88:151	13.2	13.1
366	Scott	2014	Series	English	Whiplash injury, occupationally disabled	148	37	9.2	/	22.3	10.8
367	Selvarajah	2014	Cross	English	Diabetic neuropathy	142	61	11.2	80:62	18.7	9
373	Sterling	2008	Cross	English	Whiplash injury	30	38	11.5	7:23	18.8	12.7
373	Sterling	2008	Cross	English	Healthy participants	30	30	8.8	6:24	12.2	5.1
376	Sullivan	2005	Cross	English	Post-herpetic neuralgia	12	70	/	4:8	20.7	9.2
376	Sullivan	2005	Cross	English	Diabetic neuropathy	19	57	/	15:4	25.5	11.7
376	Sullivan	2005	Cross	English	Post-surgical/post-traumatic pain	49	47	/	22:27	26.2	11.9
380	Sullivan	2002	Cross	English	Whiplash injury	65	35	7.1	25:40	32.2	10.9
381	Sullivan	2002	Cross	English	Chronic pain, chronicity less than 2 years	44	36	7.5	/	29.1	11.3
381	Sullivan	2002	Cross	English	Chronic pain, chronicity more than 4 years	51	39	8.3	/	31.3	10.7
381	Sullivan	2002	Cross	English	Chronic pain, chronicity 2-4 years	55	34	9.2	/	31.9	11.3
382	Sullivan	2000	Other	English	Healthy participants, college students, men	53	/	/	53:0	16.6	7.7
382	Sullivan	2000	Other	English	Healthy participants, college students, women	55	/	/	0:55	20.5	8.9
383	Sullivan	2000	Other	English	Healthy participants, college students, men	38	/	/	38:0	17.6	10.3
383	Sullivan	2000	Other	English	Healthy participants, college students, women	42	/	/	0:42	26.6	10.4

384	Sullivan	2008	Rct	English	Post-herpetic, diabetic, or post-traumatic neuralgia	22		52	16.3	11:10	24.2	10.8
384	Sullivan	2008	Rct	English	Post-herpetic, diabetic, or post-traumatic neuralgia	24		55	12.6	15:9	25.2	11.4
385	Sullivan	1998	Cross	English	Soft-tissue injuries to the neck, shoulders or back following work or motor vehicle accidents	86		36	7.8	27:59	28	12.8
388	Swinkels-Meewisse	2006	Series	Dutch	Acute lower back pain	93		45	11.5	45:48	18.8	12
391	Tetsunaga	2015	Series	Japanese	Intractable chronic pain, adaptive group	37		56	14	15:22	33.7	6.6
391	Tetsunaga	2015	Series	Japanese	Intractable chronic pain, dropout group	16		50	15	5:11	37.5	6.8
392	Teunis	2015	Series	English	After distal radius fracture surgery	116		55	14	31:85	17	5.9
393	Thorn	2004	Other	English	Healthy participants, students, men	90	/		/		90:0	15.3	9.8
393	Thorn	2004	Other	English	Healthy participants, students, women	129	/		/		0:129	21.9	10.4
394	Tomkins-Lane	2015	Series pilot	English	Lumbar spinal stenosis	10		68	6.7	4:6	7.9	5.7
395	Torres	2015	Rct	Spanish	Fibromyalgia, experimental group	24		53	10.3	5:19	23.5	13.5
395	Torres	2015	Rct	Spanish	Fibromyalgia, control group	24		53	7.7	4:20	28.3	12.3
396	Touche	2015	Cohort	Spanish	Headache attributed to temporomandibular disorder, mild neck	42		41	12.9	25:17	15.8	4

					disability							
396	Touche	2015	Cohort	Spanish	Headache attributed to temporomandibular disorder, moderate neck disability	41	44	10.9	15:26	17.1	3.8	
396	Touche	2015	Cohort	Spanish	Healthy participants	39	41	10	13:26	5.5	1.8	
398	Trompetter	2015	Rct	Dutch	Chronic pain	79	52	11.8	19:60	17.6	10.2	
398	Trompetter	2015	Rct	Dutch	Chronic pain	82	53	13.3	19:63	18.6	9.5	
398	Trompetter	2015	Rct	Dutch	Chronic pain	77	53	12	19:58	19.1	9.6	
399	Turner	2013	Cross	English	Rheumatoid arthritis	32	55	15.7	8:24	21	11	
399	Turner	2013	Cross	English	Healthy participants	28	47	11.8	7:21	8	8	
400	Vaisy	2015	Cross	German	Low back pain	20	33	9.6	19:11	13.9	8.9	
401	van Damme	2014	Cross	English	Persistent non-specific low back pain, good performers on muscle endurance task	120	42	8.1	/	15.9	9.3	
401	van Damme	2014	Cross	English	Persistent non-specific low back pain, underperformers on muscle endurance task	212	42	8.1	/	18.5	9.8	
404	van Ittersum	2011	Series	Dutch	Fibromyalgia	41	/	/	3:38	15.2	11.4	
405	van Ittersum	2014	Rct	Dutch	Fibromyalgia	52	46	9.8	4:48	23	12.1	
405	van Ittersum	2014	Rct	Dutch	Fibromyalgia	53	48	9.1	3:50	24	11.9	
407	Vancleef	2006	Cross	Dutch	Healthy participants,	48	22	4.4	12:36	14.2	7.8	

					university local community							
410	Vincent	2014	Rct	English	Obese adults with chronic low back pain	17	69	7.3	5:12	11.5	12.6	
410	Vincent	2014	Rct	English	Obese adults with chronic low back pain	14	68	6.4	5:9	12.5	11.7	
410	Vincent	2014	Rct	English	Obese adults with chronic low back pain	18	69	7.1	6:12	13.2	12.7	
413	Vowles	2013	Cross	English	Chronic pain	334	46	11.4	126:208	25.3	17.3	
414	Vranceanu	2014	Series	English	One to two months after muskuloskeletal trauma surgery	136	48	17.3	63:73	19.1	8.7	
415	Vranceanu	2015	Rct	English	Musculoskeletal trauma within last 1-2 months, experimental group	24	/	/	/	14.8	9.9	
415	Vranceanu	2015	Rct	English	Musculoskeletal trauma within last 1-2 months, control group	10	/	/	/	15.7	11.2	
418	Walker	2014	Cross	English	Spinal pain	183	55	14.5	116:67	15.1	10.6	
420	Walton	2013	Psychometric	English	Patients with work-related pain conditions	235	37	10	88:147	21.7	10.9	
421	Watson	2008	Cross	English	Isolated, discrete upper-extremity condition	134	50	13	83:51	19.3	7.3	
423	Witvrouw	2009	Series	Dutch	Preoperative, total knee arthroplasty	43	61	/	17:26	20.2	9.7	
424	Wong	2013	Cross	Chinese	Chronic pain	224	46	9.9	100:124	24.6	14.3	

425	Zhao	2012	Other	English	Healthy participants, experimental group	13	30	4.9	6:7	8.2	6
425	Zhao	2012	Other	English	Healthy participants, control group	13	30	3.4	6:7	12.6	13.6

Appendix C

Table of quality measures of the studies that failed to meet any one of the three markers of sample-related internal validity

Note: Y = yes (criterion fulfilled); N = no (criterion not fulfilled); CD = cannot determine; NA = not applicable; NR = not reported

Study ID	Author	Year	Q1	Q2	Q3
3	A. Barke, J. Riecke, W. Rief and J. A. Glombiewski	2015	y	CD	y
8	N. Kikuchi, K. Matsudaira, T. Sawada and H. Oka	2015	y	y	n
10	H. Kjogx, R. Zachariae, M. Pfeiffer-Jensen, H. Kasch, P. Svensson, T. S. Jensen and L. Vase	2014	y	NR	y
11	B. S. Koo, M. J. Jung, J. H. Lee, H. C. Jin, J. S. Lee and Y. I. Kim	2015	y	NR	y
17	R. A. Lopes, R. C. Dias, B. Z. De Queiroz, N. M. De Britto Rosa, L. S. M. Pereira, J. M. D. Dias and L. C. Magalhaes	2015	y	NR	y
19	A. Maric, A. Banozic, A. Cosic, S. Kraljevic, D. Sapunar and L. Puljak	2011	y	NR	y
20	K. Matsudaira, N. Kikuchi, A. Murakami and T. Isomura	2014	y	n	y
25	F. H. Mohd Din, V. C. W. Hoe, C. K. Chan and M. A. Muslan	2015	n	NA	n
35	M. Penhoat, A. Saraux, B. Le Goff, P. Augereau, Y. Maugars and J. M. Berthelot	2014	y	NR	y
37	B. Rodero, J. Garcia-Campayo, B. Casanueva, Y. L. del Hoyo, A. Serrano-Blanco and J. V. Luciano	2010	y	NR	y
38	B. Rodero, J. V. Luciano, J. Montero-Marin, B. Casanueva, J. C. Palacin, M. Gili, Y. L. del Hoyo, A. Serrano-Blanco and J. Garcia-Campayo	2012	y	NR	y
40	J. Roelofs, M. L. Peters, L. McCracken and J. W. Vlaeyen	2003	y	n	n
41	J. Roelofs, M. L. Peters, P. Muris and J. W. S. Vlaeyen	2002	y	NR	n
42	A. A. Rogulj, I. Richter, V. Brailo, I. Krstevski and V. V. Boras	2014	y	NR	y
43	F. Sehn, E. Chachamovich, L. P. Vidor, L. Dall-Agnol, I. C. C. de Souza,	2012	y	NR	y

	I. L. S. Torres, F. Fregni and W. Caumo				
44	R. Severeijns, M. A. van den Hout, J. W. Vlaeyen and H. Picavet	2002	y	n	y
46	M. Suren, I. Okan, A. M. Gokbakan, Z. Kaya, U. Erkorkmaz, S. Arici, S. Karaman and M. Kahveci	2014	y	NR	y
48	S. Van Damme, G. Crombez, P. Bijttebier, L. Goubert and B. Van Houdenhove	2002	y	NR	n
49	M. S. Volz, L. F. Medeiros, M. da Graca Tarrago, L. P. Vidor, L. Dall`Agnol, A. Deitos, A. Brietzke, J. R. Rozisky, B. Rispolli, I. L. Torres, F. Fregni and W. Caumo	2013	y	CD	y
50	W. S. Wong, Y. F. Chow, P. P. Chen, S. Wong and R. Fielding	2015	y	NR	y
56	Jin-Ho Park, Hye-Kyoung Kim, Ki-Suk Kim, Mee-Eun Kim	2015	y	NR	y
66	L. Aerts, S. Bergeron, S. Corsini-Munt, M. Steben and M. Paquet	2015	y	NR	y
67	R. Akhter, J. Benson, P. Svensson, M. K. Nicholas, C. C. Peck and G. M. Murray	2014	y	CD	y
69	M. J. Alappattu, S. Z. George, M. E. Robinson, R. B. Fillingim, N. Moawad, E. W. Lebrun and M. D. Bishop	2015	y	CD	y
70	V. Albert, M. F. Coutu and M. J. Durand	2013	y	NA	y
71	A. Al-Kaisy, S. Palmisani, T. Smith, S. Harris and D. Pang	2015	y	NR	y
77	J. Baranoff, S. J. Hanrahan and J. P. Connor	2015	y	NR	y
78	AuK. J. Barnhoorn, J. B. Staal, R. T. M. Dongen, J. P. M. Frolke, F. P. Klomp, H. Meent, H. Samwel and M. W. G. Nijhuis-van Der Sandenthor	2015	y	NR	y
87	J. M. Beneciuk, M. E. Robinson and S. Z. George	2012	y	NR	y
89	C. Berna, K. Vincent, J. Moore, I. Tracey, G. M. Goodwin and E. A. Holmes	2011	y	NR	y
90	M. Bhaskaracharya, S. M. Memon, T. Whittle and G. M. Murray	2015	y	NR	y
91	E. Billis, C. J. McCarthy, C. Roberts, J. Gliatis, M. Papandreou, G. Gioftsos and J. A. Oldham	2013	y	NA	y
92	C. K. Block and J. Brock	2008	y	NA	y
96	C. Borg, M. L. Peters, W. W. Schultz and P. J. de Jong	2012	y	CD	y

98	G. P. Bostick, L. J. Carroll, C. A. Brown, D. Harley and D. P. Gross	2013	y	NR	y
101	A. G. J. Bot, J. A. Anderson, V. Neuhaus and D. Ring	2013	y	NR	y
103	A. G. J. Bot, S. Ferree, V. Neuhaus and D. Ring	2013	n	NR	n
108	D. A. Brandini, J. Benson, M. K. Nicholas, G. M. Murray and C. C. Peck	2011	y	NR	n
120	C. M. Campbell, T. Kronfli, L. F. Buenaver, M. T. Smith, C. Berna, J. A. Haythornthwaite and R. R. Edwards	2010	y	NR	y
123	E. M. Carroll, S. K. Kamboj, L. Conroy, A. Tookman, A. C. Williams, L. Jones, C. J. Morgan and H. V. Curran	2011	y	NR	y
125	B. Carvalho, M. Zheng and L. Aiono-Le Tagaloa	2014	y	NR	y
128	P. P. Casey, A. M. Feyer and I. D. Cameron	2015	y	n	y
130	A. Cebolla, J. V. Luciano, M. P. DeMarzo, M. Navarro-Gil and J. G. Campayo	2013	y	NR	y
135	D. K. Chatkoff, M. T. Leonard and K. J. Maier	2015	y	NR	y
140	S. G. Choobmasjedi, J. Hasani, M. Khorsandi and M. Ghobadzadeh	2012	y	NA	y
142	K.-F. Chung, K.-C. Tso, W.-F. Yeung and W.-H. Li	2012	y	NR	y
143	K.-F. Chung, Y.-M. Yu and W.-F. Yeung	2015	y	NR	y
149	A. Cosic, L. Ferhatovic, A. Banozic, S. Kraljevic, A. Maric, D. Sapunar and L. Puljak	2013	y	NR	y
151	S. Curran, L. A. Brotto, H. Fisher, G. Knudson and T. Cohen	2010	y	NA	y
154	B. D. Darnall and E. Sazie	2012	y	CD	y
155	B. D. Darnall, J. A. Sturgeon, M. C. Kao, J. M. Hah and S. C. Mackey	2014	y	y	n
159	M. A. Davidson, D. A. Tripp, L. R. Fabrigar and P. R. Davidson	2008	y	NR	y
161	S. N. Davis, S. Bergeron, K. Bois, G. Sadikaj, Y. M. Binik and M. Steben	2015	y	CD	y
165	M. J. De Boer, H. E. Steinhagen, G. J. Versteegen, R. Sanderman and M. M. R. F. Struys	2014	y	NR	y
176	Z. Dimitriadis, N. Strimpakos, E. Kapreli and J. Oldham	2014	y	NA	y
179	K. E. Dixon, B. E. Thorn and L. Ward	2004	y	NR	y
193	C. H. Feldman, Y. Dong, J. N. Katz, L. A. Donnell-Fink and E. Losina	2015	y	NR	n
195	L. Fernandes, K. Storheim, I. Lochting and M. Grotle	2012	y	NR	y

199	I. K. Flink, M. Z. Mroczek, M. J. Sullivan and S. J. Linton	2009	y	NR	y
201	J. M. Fritz, J. S. Magel, M. McFadden, C. Asche, A. Thackeray, W. Meier and G. Brennan	2015	y	CD	y
202	C. M. Gagnon, S. P. Stanos, G. van der Ende, L. R. Rader and R. N. Harden	2013	y	NR	y
207	N. Gauthier, P. Thibault and M. J. L. Sullivan	2011	y	CD	y
209	S. Z. George, D. Calley, C. Valencia and J. M. Beneciuk	2011	y	NA	y
212	N. Geva and R. Defrin	2013	y	NR	n
214	W. Gilliam, J. W. Burns, P. Quartana, J. Matsuura, C. Nappi and B. Wolff	2010	y	CD	y
215	B. R. Goodin, R. B. Fillingim, S. Machala, L. McGuire, L. F. Buenaver, C. M. Campbell and M. T. Smith	2011	y	CD	y
223	K. Hayashi, Y.-C. P. Arai, A. Morimoto, S. Aono, T. Yoshimoto, M. Nishihara, T. Osuga, S. Inoue and T. Ushida	2015	y	y	n
224	D. Hegarty, D. Coakley and I. Dooley	2014	y	n	y
226	K. L. Herbst and T. Rutledge	2010	y	NA	y
228	R. Hiebert, M. A. Campello, S. Weiser, G. W. Ziemke, B. A. Fox and M. Nordin	2012	y	N	y
230	A. T. Hirsh, S. Z. George, J. E. Bialosky and M. E. Robinson	2008	y	NR	y
238	S. Horsham and M. C. Chung	2013	y	CD	y
242	A. Kao, Y. M. Binik, R. Amsel, D. Funaro, N. Leroux and S. Khalife	2012	y	CD	y
244	N. V. Karayannis, R. J. E. M. Smeets, W. van den Hoorn and P. W. Hodges	2013	y	CD	y
246	P. A. Karsdorp and J. W. Vlaeyen	2009	y	NR	y
254	H. J. Kim, S. C. Kim, K. T. Kang, B. S. Chang, C. K. Lee and J. S. Yeom	2014	y	NR	y
256	V. Kleiman, H. Clarke and J. Katz	2011	y	NR	y
263	R. La Touche, J. Pardo-Montero, A. Gil-Martinez, A. Paris-Alemany, S. Angulo-Diaz-Parreno, J. C. Suarez-Falcon, M. Lara-Lara and J. Fernandez-Carnero	2014	y	NA	y
264	I. E. Lame, M. L. Peters, A. G. Kessels, M. van Kleef and J. Patijn	2008	y	NA	n

265	C. Lariviere, M. Bilodeau, R. Forget, R. Vadeboncoeur and H. Mecheri	2010	y	NR	y
268	J. Lee, D. Watson and L. Frey-Law	2013	y	NR	y
269	A. J. Lemieux, S. Bergeron, M. Steben and B. Lambert	2013	y	CD	y
270	M. T. Leonard, D. K. Chatkoff and M. Gallaway	2013	y	NR	y
271	C. S. Lin, D. M. Niddam, M. L. Hsu and J. C. Hsieh	2013	y	CD	y
272	A. Lindenhovius, M. Henket, B. P. Gilligan, S. Lozano-Calderon, J. B. Jupiter and D. Ring	2008	y	n	y
282	M. Theunissen, M. A. E. Marcus, P. R. Pinto, M. L. Peters, E. G. W. Schouten, A. A. A. Fiddelers, M. G. A. Willemsen and H.-F. Gramke	2014	y	NR	y
283	M. O. Martel, A. D. Wasan and R. R. Edwards	2013	y	NR	y
284	A. L. Martin, E. Halket, G. J. Asmundson, D. B. Flora and J. Katz	2010	y	NR	n
285	M. Martinez, E. Miro, A. I. Sanchez, A. Mundo and E. Martinez	2012	y	NR	y
289	M. J. McLoughlin, L. H. Colbert, A. J. Stegner and D. B. Cook	2011	y	CD	y
290	L. A. McWilliams and G. J. Asmundson	2007	y	NR	y
291	L. A. McWilliams, J. Kowal, D. Sharpe and B. D. Dick	2014	y	NA	y
292	L. A. McWilliams, J. Kowal and K. G. Wilson	2015	y	NA	y
293	M. Meeus, J. Nijs, J. Van Oosterwijck, V. Van Alsenoy and S. Truijen	2010	y	NR	y
302	D. J. Moore, C. Eccleston and E. Keogh	2013	y	NR	y
303	G. Moseley	2004	y	NA	y
304	AuG. L. Moseley, M. K. Nicholas and P. W. Hodgesthor	2004	y	CD	y
309	M. Nakamura, Y. Nishiwaki, M. Sumitani, T. Ushida, T. Yamashita, S. Konno, T. Taguchi and Y. Toyama	2014	y	y	n
310	K. M. Naugle, K. E. Naugle, R. B. Fillingim and J. L. Riley, III	2014	y	CD	y
312	J. C. Nickel, D. A. Tripp, M. Pontari, R. Moldwin, R. Mayer, L. K. Carr, R. Doggweiler, C. C. Yang, N. Mishra and J. Nordling	2010	y	NR	y
316	T. Nishigami, A. Mibu, M. Osumi, K. Son, S. Yamamoto, S. Kajiwara, K. Tanaka, A. Matsuya and A. Tanabe	2015	y	NR	y
318	C. B. Novak, D. J. Anastakis, D. E. Beaton, S. E. Mackinnon and J. Katz	2012	y	NR	y
319	C. B. Novak, D. J. Anastakis, D. E. Beaton, S. E. Mackinnon and J. Katz	2013	y	NR	y

325	A. Osman, F. X. Barrios, P. M. Gutierrez, B. A. Kopper, T. Merrifield and L. Grittmann	2000	y	NR	y
326	A. Osman, F. X. Barrios, B. A. Kopper, W. Hauptmann, J. Jones and E. O'Neill	1997	y	NR	y
328	J. J. Parr, P. A. Borsa, R. B. Fillingim, M. D. Tillman, T. M. Manini, C. M. Gregory and S. Z. George	2012	y	NR	y
330	D. Pavlin, M. J. Sullivan, P. R. Freund and K. Roesen	2005	y	NR	y
331	I. Pearson, A. Reichert, S. J. De Serres, J. P. Dumas and J. N. Cote	2009	y	CD	y
333	T. J. Phillips, M. Brown, J. D. Ramirez, J. Perkins, Y. W. Woldeamanuel, A. C. Williams, C. Orengo, D. L. Bennett, I. Bodi, S. Cox, C. Maier, E. K. Krumova and A. S. Rice	2014	y	NR	y
334	T. Pincus, A. Rusu and R. Santos	2008	y	NR	y
335	M. Plazier, I. Dekelver, S. Vanneste, G. Stassijns, T. Menovsky, M. Thimineur and D. De Ridder	2014	y	NR	y
337	J. Prugh, G. Zeppieri Jr and S. Z. George	2012	y	NR	y
338	C. Pukall, K. Kandyba, R. Amsel, S. Khalife and Y. Binik	2007	y	CD	y
339	R. Raak and M. Wallin	2006	y	NR	y
341	J. E. Rayahin, J. S. Chmiel, K. W. Hayes, O. Almagor, L. Belisle, A. H. Chang, K. Moisio, Y. Zhang and L. Sharma	2014	y	NR	y
343	D. Ring, J. Kadzielski, L. Malhotra, S. G. P. Lee and J. B. Jupiter	2005	y	NR	y
344	K. Rivest, J. N. Cote, J. P. Dumas, M. Sterling and S. J. De Serres	2010	y	CD	y
346	T. F. Robles, R. Sharma, K. S. Park, L. Harrell, M. Yamaguchi and V. Shetty	2012	y	NR	y
347	B. Rodero, J. Campayo, B. Fernandez and N. Sobradiel	2008	y	NR	y
351	J. C. Rosenberg, D. M. Schultz, L. E. Duarte, S. M. Rosen and A. Raza	2015	y	NR	y
353	M. L. Roth, D. A. Tripp, M. H. Harrison, M. Sullivan and P. Carson	2007	y	y	n
355	G. T. Ruiz-Parraga and A. E. Lopez-Martinez	2014	y	n	y
356	R. Ruscheweyh, F. Nees, M. Marziniak, S. Evers, H. Flor and S. Knecht	2011	y	CD	y
357	A. I. Sanchez, M. Martinez, E. Miro and A. Medina	2011	y	NR	y

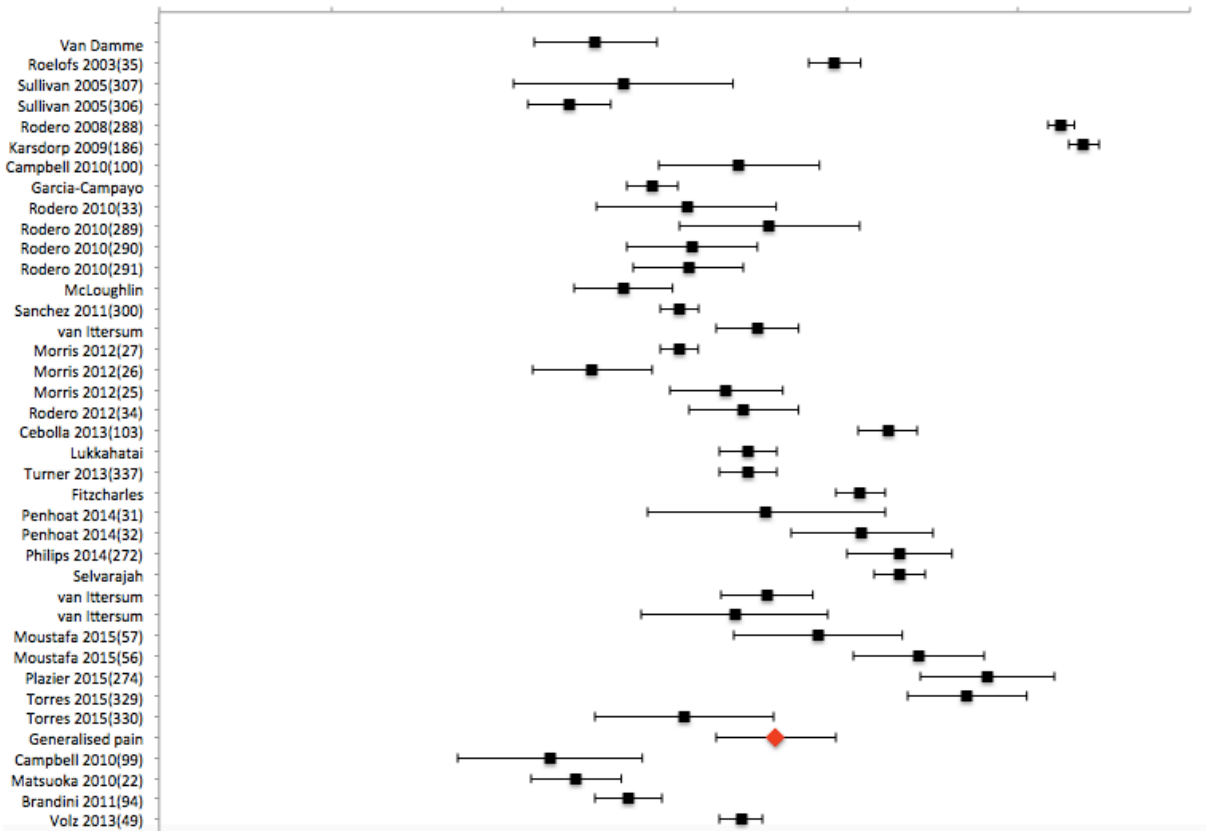
366	W. Scott, T. H. Wideman and M. J. Sullivan	2014	y	NR	y
373	M. Sterling, E. Hodkinson, C. Pettiford, T. Souvlis and M. Curatolo	2008	y	CD	y
376	M. J. Sullivan, M. E. Lynch and A. Clark	2005	y	NR	y
380	M. J. Sullivan, W. Stanish, M. E. Sullivan and D. Tripp	2002	y	NR	y
381	M. J. Sullivan, M. E. Sullivan and H. M. Adams	2002	y	NA	y
382	M. J. Sullivan, D. A. Tripp, W. M. Rodgers and W. Stanish	2000	y	NR	y
383	M. J. Sullivan, D. A. Tripp and D. Santor	2000	y	NR	y
384	M. J. L. Sullivan, M. E. Lynch, A. J. Clark, T. Mankovsky and J. Sawynok	2008	y	NR	n
385	M. J. L. Sullivan, W. Stanish, H. Waite, M. Sullivan and D. A. Tripp	1998	y	NA	y
388	I. E. Swinkels-Meewisse, J. Roelofs, R. A. Oostendorp, A. L. Verbeek and J. W. Vlaeyen	2006	y	NR	y
391	T. Tetsunaga, T. Tetsunaga, H. Nishie and T. Ozaki	2015	y	NR	y
392	T. Teunis, A. G. J. Bot, E. R. Thornton and D. Ring	2015	y	NR	y
393	B. E. Thorn, K. L. Clements, L. Ward, K. E. Dixon, B. C. Kersh, J. L. Boothby and W. F. Chaplin	2004	y	NR	y
394	C. C. Tomkins-Lane, L. M. Z. Lafave, J. A. Parnell, J. Rempel, S. Moriartey, Y. Andreas, P. M. Wilson, C. Hepler, H. A. Ray and R. Hu	2015	y	NR	y
396	R. L. Touche, A. Paris-Alemany, A. Gil-Martinez, J. Pardo-Montero, S. Angulo-Diaz-Parreno and J. Fernandez-Carnero	2015	y	NA	y
399	L. Turner, W. Linden and C. Marshall	2013	y	NR	y
400	M. Vaisy, L. Gizzi, F. Petzke, T. Consmuller, M. Pfingsten and D. Falla	2015	y	NR	y
401	B. Van Damme, V. Stevens, D. Van Tiggelen, C. Perneel, G. Crombez and L. Danneels	2014	y	NR	y
407	L. M. Vancleef and M. L. Peters	2006	y	CD	y
413	K. E. Vowles, L. M. McCracken and C. Eccleston	2008	y	NR	n
414	A. M. Vranceanu, A. Bachoura, A. Weening, M. Vrahas, R. M. Smith and D. Ring	2014	y	NR	y
418	B. F. Walker, C. D. Losco, A. Armson, A. Meyer and N. J. Stomski	2014	y	NR	y

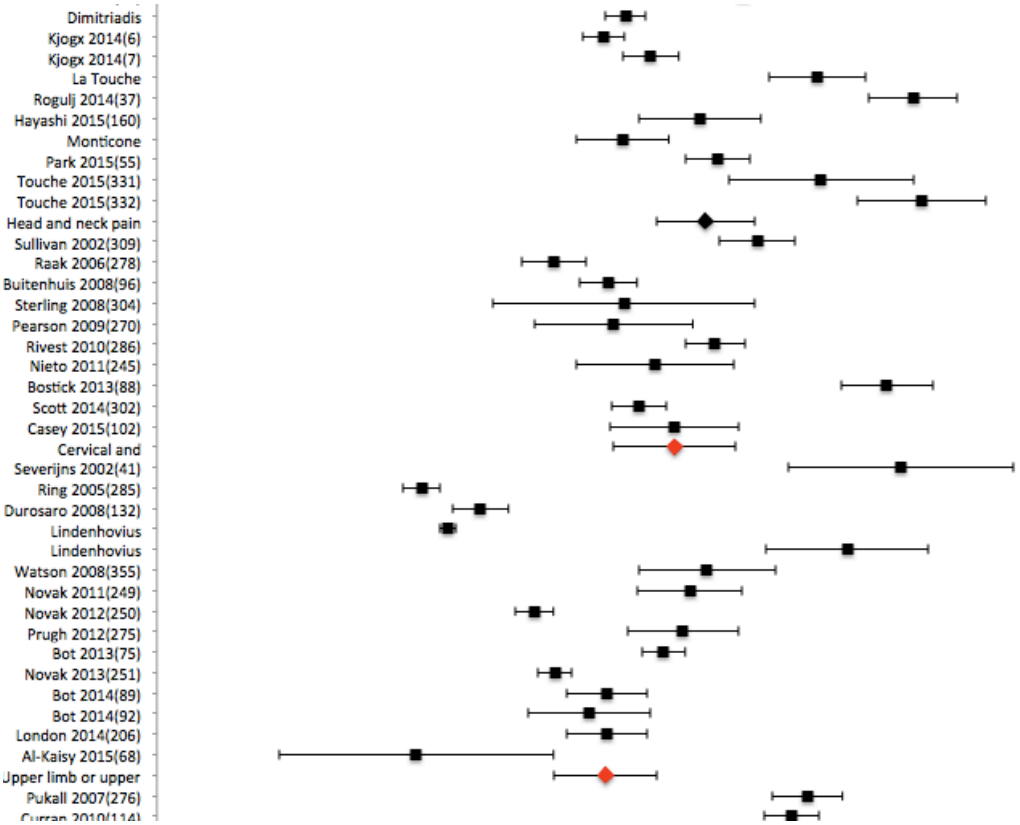
420	D. M. Walton, T. H. Wideman and M. J. Sullivan	2013	y	NR	n
421	J. Watson and D. Ring	2008	y	NR	y
424	W. S. Wong and R. Fielding	2013	y	NR	y
425	N. Zhao, T. Whittle, G. M. Murray and C. C. Peckthor	2012	y	NR	y

Appendix D

Forest plot showing the weighted mean PCS score and 95% confidence intervals for all participant groups included in the review and meta-analysis

Note: The Y-axis label shows the first author, publication year, and case ID for the participant group. The plot runs across several pages in order to display all participant groups

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Raak 2006(278)
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Sterling 2008(304)
Pearson 2009(270)
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Scott 2014(302)
Casey 2015(102)
Cervical and
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Ring 2005(285)
Durosaro 2008(132)
Lindenhovius
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Watson 2008(355)
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Prugh 2012(275)
Bot 2013(75)
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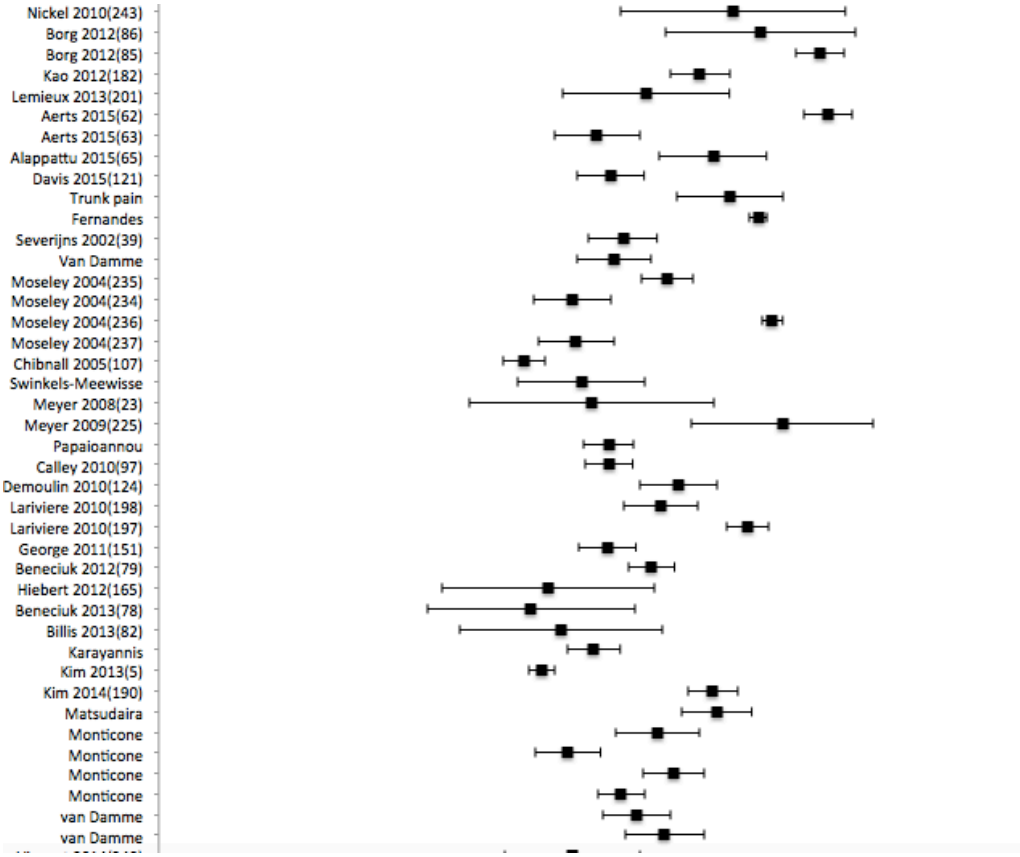
London 2014(206)
Al-Kaisy 2015(68)
Upper limb or upper
Pukall 2007(276)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Borg 2012(86)
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Alappattu 2015(65)
Davis 2015(121)
Trunk pain
Fernandes
Severijns 2002(39)
Van Damme
Moseley 2004(235)
Moseley 2004(234)
Moseley 2004(236)
Moseley 2004(237)
Chibnall 2005(107)
Swinkels-Meewisse
Meyer 2008(23)
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Papaioannou
Calley 2010(97)
Demoulin 2010(124)
Lariviere 2010(198)
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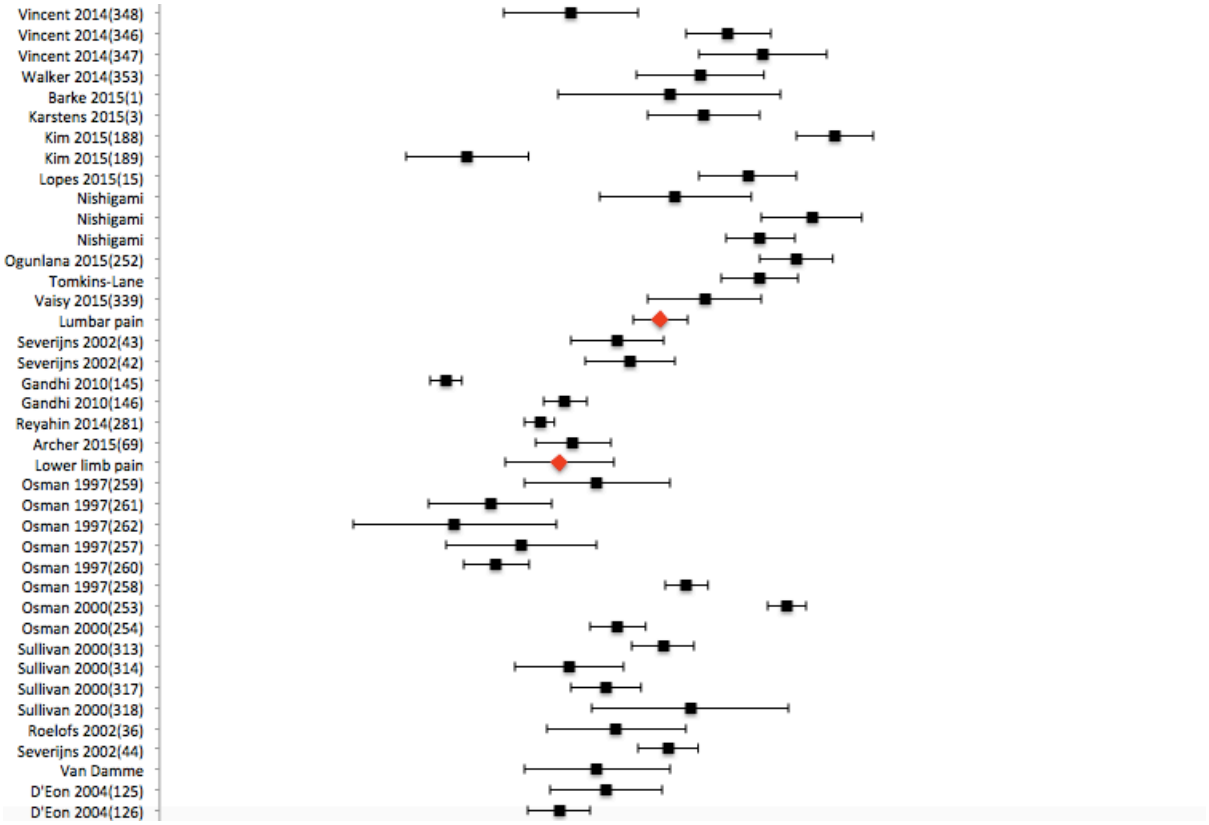
George 2011(151)
Beneciuk 2012(79)
Hiebert 2012(165)
Beneciuk 2013(78)
Billis 2013(82)
Karayannis
Kim 2013(5)
Kim 2014(190)
Matsudaira
Monticone
Monticone
Monticone
Monticone
van Damme
van Damme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Barke 2015(1)
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Lopes 2015(15)
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Ogunlana 2015(252)
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Vaisy 2015(339)
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Reyahin 2014(281)
Archer 2015(69)
Lower limb pain
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Sullivan 2000(314)
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Van Damme
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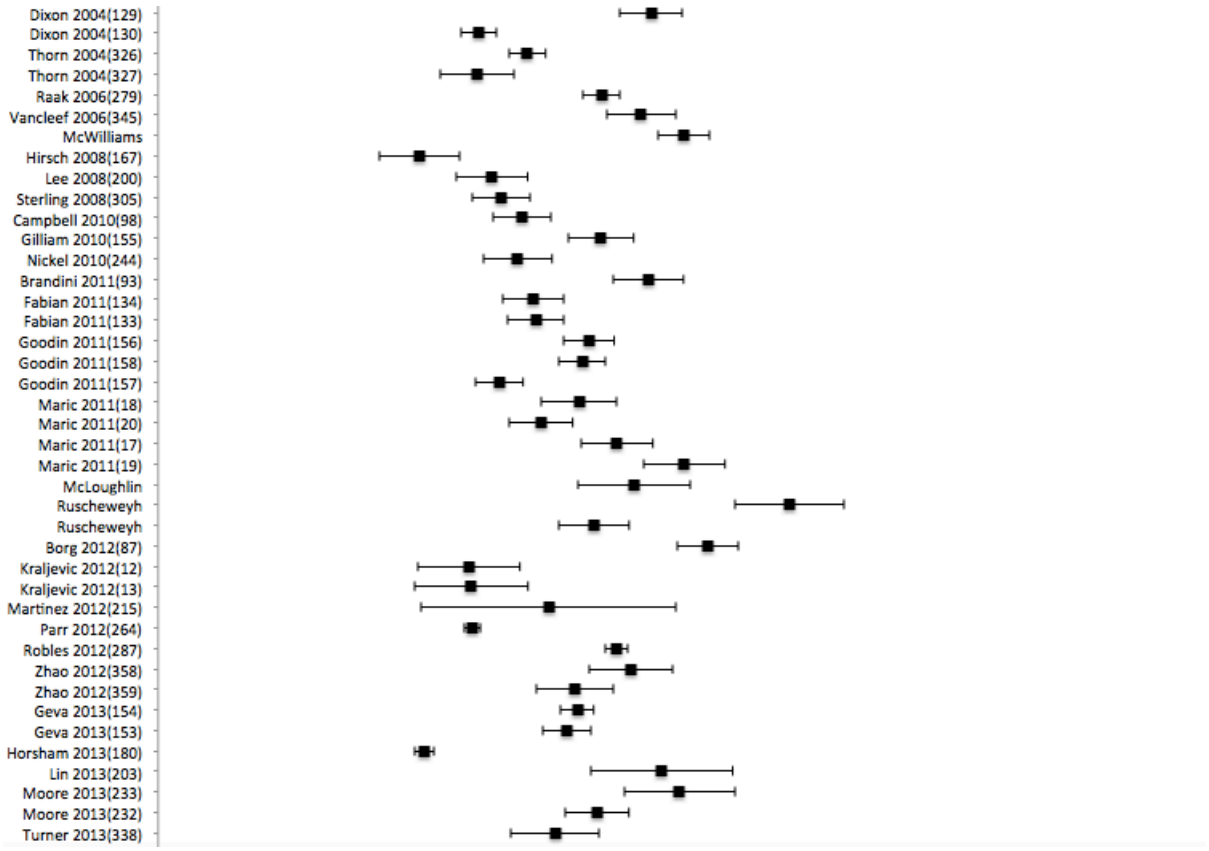
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Goodin 2011(157)
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McLoughlin
Ruscheweyh
Ruscheweyh
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Moore 2013(233)
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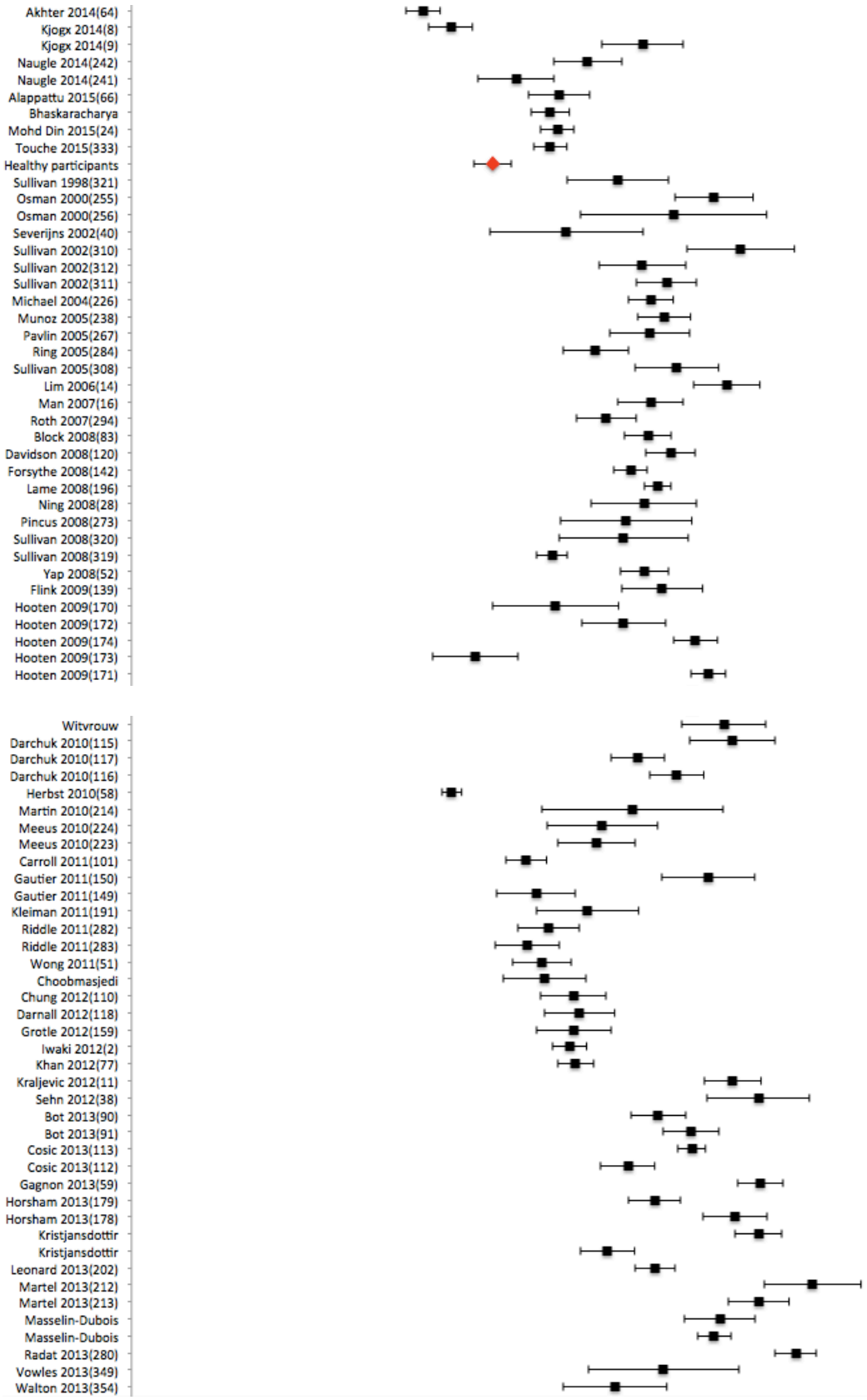
Turner 2013(338)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Alappattu 2015(66)
Bhaskaracharya
Mohd Din 2015(24)
Touche 2015(333)
Healthy participants
Sullivan 1998(321)
Osman 2000(255)
Osman 2000(256)
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Michael 2004(226)
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Pavlin 2005(267)
Ring 2005(284)
Sullivan 2005(308)
Lim 2006(14)
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Pincus 2008(273)
Sullivan 2008(320)
Sullivan 2008(319)
Yap 2008(52)
Flink 2009(139)
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Herbst 2010(58)
Martin 2010(214)
Meeus 2010(224)
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Carroll 2011(101)
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Kleiman 2011(191)
Riddle 2011(282)
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Wong 2011(51)
Choobmasjedi
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Bot 2013(90)
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Cosic 2013(113)
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Gagnon 2013(59)
Horsham 2013(179)
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Kristjansdottir
Kristjansdottir
Leonard 2013(202)
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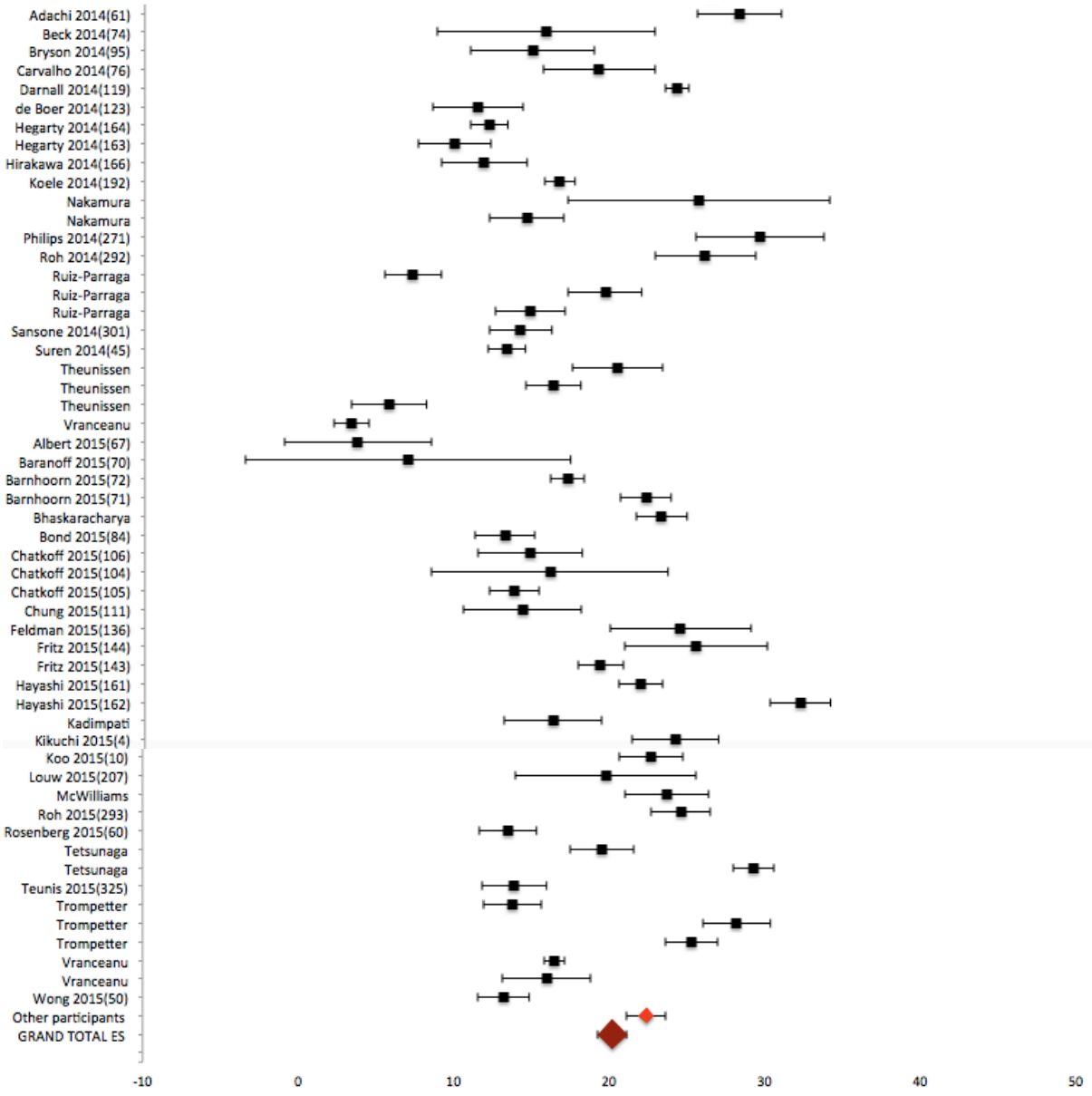
Radat 2013(280)
Vowles 2013(349)
Walton 2013(354)



Weighted mean PCS score

Appendix E

Norms for PCS total scale scores for healthy people and for people with different pain diagnoses

Norms for healthy people (people with no pain diagnosis)

Norm name	Total number	Males	Females	Undeclared
Healthy	7,742	2,403 (31.0%)	3,977 (51.4%)	1,362 (17.6%)

Weighted mean age	Weighted SD age
29.64	7.48

Language of PCS completed		
English	3844	(49.7%)
Dutch	1816	(23.5%)
Croatian	855	(11.0%)
Spanish	510	(6.6%)
Other	470	(6.1)

Scale statistics	Weighted mean	Weighted standard deviation
PCS total score	15.18	3.50

Norms for people with generalized pain

Norm name	Total number	Males	Females	Undeclared
Generalised pain	3,404	450 (13.2%)	2,533 (74.4%)	421 (12.4%)

Weighted mean age	Weighted SD age
49.48	9.68

Language of PCS completed		
Spanish	1,414	(41.5%)
Dutch	1,056	(31.0%)
English	690	(20.3%)
French	140	(4.1%)
Other	104	(3.1%)

Scale statistics	Weighted mean	Weighted standard deviation
PCS total score	25.88	4.36

Norms for people with head and neck pain

Norm name	Total number	Males	Females	Undeclared
Head and neck pain	1,036	282 (27.2%)	754 (72.8%)	0 (0%)

Weighted mean age	Weighted SD age
45.62	13.22

Language of PCS completed		
Spanish	275	(26.5%)
Danish	218	(21.0%)
Korean	155	(15.0%)
Italian	118	(11.4%)
Japanese	108	(10.4%)
English	63	(6.1%)
Greek	45	(4.3%)
Other	54	(5.2%)

Scale statistics	Weighted mean	Weighted standard deviation
PCS total score	21.71	5.07

Norms for people with cervical and thoracic pain

Norm name	Total number	Males	Females	Undeclared
Cervical and thoracic pain	916	213 (23.3%)	555 (60.6%)	148 (16.2%)

Weighted mean age	Weighted SD age
38.16	11.32

Language of PCS completed		
English	752	(82.1%)
Spanish	147	(16.0%)
Swedish	17	(1.9%)

Scale statistics	Weighted mean	Weighted standard deviation
PCS total score	19.93	10.66

Norms for people with upper limbs or upper and lower limb pain

Norm name	Total number	Males	Females	Undeclared
Upper limbs or upper and lower limb pain	2,874	1,101 (38.3%)	1,293 (45.0%)	480 (16.7%)

Weighted mean age	Weighted SD age
45.53	13.28

Language of PCS completed		
English	2,394	(83.3%)
Dutch	480	(16.7%)

Scale statistics	Weighted mean	Weighted standard deviation
PCS total score	15.94	8.44

Norms for people with trunk pain

Norm name	Total number	Males	Females	Undeclared
Trunk pain	1,157	0 (0%)	1,157 (100%)	0 (0%)

Weighted mean age	Weighted SD age
33.33	8.14

Language of PCS completed		
English	728	(62.9%)
French	179	(15.5%)
Dutch	68	(5.9%)
Other	182	(15.7%)

Scale statistics	Weighted mean	Weighted standard deviation
PCS total score	22.96	10.11

Norms for people with lumbar pain

Norm name	Total number	Males	Females	Undeclared
Lumbar pain	7,631	3,240 (42.5%)	3,326 (43.6%)	1,065 (14.0%)

Weighted mean age	Weighted SD age

50.48	11.10	

Language of PCS completed		
English	3,322	(43.5%)
Japanese	1,828	(24.0%)
Dutch	1,108	(14.5%)
German	619	(8.1%)
Korean	322	(4.2%)
Italian	150	(2.0%)
Brazilian Portuguese	131	(1.7%)
Other	151	(2.0%)

Scale statistics	Weighted mean	Weighted standard deviation
PCS total score	19.05	9.02

Norms for people with lower limb pain

Norm name	**Total number**	**Males**	**Females**	**Undeclared**
Lower limb pain	1,412	200 (14.2%)	346 (24.5%)	866 (61.3%)

Weighted mean age	**Weighted SD age**
59.76	11.03

Language of PCS completed		
Dutch	866	(61.3%)
English	546	(38.7%)

Scale statistics	Weighted mean	Weighted standard deviation
PCS total score	13.22	8.87

Appendix F

References of studies included in the review and meta-analysis

Aerts, L., Bergeron, S., Corsini-Munt, S., Steben, M., & Paquet, M. (2015). Are primary and secondary provoked vestibulodynia two different entities? A comparison of pain, psychosocial, and sexual characteristics. Journal of Sexual Medicine, 12(6), 1463-1473.

Akhter, R., Benson, J., Svensson, P., Nicholas, M. K., Peck, C. C., & Murray, G. M. (2014). Experimental jaw muscle pain increases pain scores and jaw movement variability in higher pain catastrophizers. Journal of oral & facial pain and headache, 28(3), 191-204.

Alappattu, M. J., George, S. Z., Robinson, M. E., Fillingim, R. B., Moawad, N., Lebrun, E. W., & Bishop, M. D. (2015). Painful Intercourse Is Significantly Associated with Evoked Pain Perception and Cognitive Aspects of Pain in Women with Pelvic Pain. Sexual Medicine, 3(1), 14-23.

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