Meta-analysis of the psychometric properties of the Pain Catastrophizing Scale and associations with participant characteristics

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Abstract

The aims of this study were to review the psychometric properties of the widely used Pain Catastrophizing Scale (PCS) using meta-analytic methods, and to investigate the relationship between PCS scores and participant characteristics. A systematic search from 1995 found 229 experimental, quasi-experimental and correlational studies that report PCS scores. Multivariate regression explored variables related to pain catastrophizing and participant demographics. Across studies, good internal reliability (α = 0.92, 95% CI 0.91 - 0.93) and test-retest reliability scores (Spearman ρ = 0.88, 95% CI 0.83 - 0.93) were found for PCS total scores but not for subscales. PCS scores were unrelated to age or gender, but strongly related to participants' pain type, highest in those with generalized pain. Language of the PCS also affected PCS scores, with further research necessary to determine linguistic, cultural or methodological (e.g. sampling strategy) influences. Study type influenced PCS scores with non-randomized controlled trials reporting higher PCS scores than other study types, but results were confounded with pain diagnosis, as controlled trials were more likely than quasi-experimental studies to recruit clinical samples. The meta-analytic results provide insight into demographic influences on pain catastrophizing scores and highlight areas for further research. The advantages of systematic review and meta-analytic methods to achieve greater understanding and precision of psychometric properties – in this case, of the PCS – are applicable to other widely used outcome tools.

Keywords

Outcome measure; PROMS; Systematic review; Reliability

1 Introduction

1.1 Pain catastrophizing

Pain catastrophizing is one of a number of concepts describing the psychological experience of pain. Beck first described catastrophizing in general as a cognitive error, or 'an irrationally negative forecast of future events' [20] (p.745). Pain catastrophizing is the forecast of future pain and a person's inability to divert attention away from the pain [13]; also described by Sullivan and colleagues as 'an exaggerated negative mental set brought to bear during actual or anticipated painful experience' [25] (p.53).

1.2 Established psychometric properties of the PCS

The Pain Catastrophizing Scale (PCS) is widely used as the 'reference standard psychometric tool for pain catastrophizing' [13]. Respondents are asked to rate 13 pain-related statements on a 5-point Likert scale. During its development, Sullivan and colleagues investigated the factor structure in a sample of 439 students [23]. Principal components analysis established that the PCS assessed three related dimensions of magnification (evaluation of the pain as a threat), rumination (repeated worry) and helplessness (belief that nothing can help to resolve the pain). Confirmatory factor analysis has since been used in English and Dutch versions to confirm this three-factor structure compared to a unidimensional or two-factor structure in students [18], community and pain outpatient samples [17], and pain-free students, chronic low back pain patients, and fibromyalgia patients [28]. Overall, these studies demonstrate consistency of the three-factor model of pain catastrophizing across participant groups in English and Dutch versions of the questionnaire.

Existing data on the reliability of the PCS reports adequate to excellent internal validity scores (coefficient alphas: total PCS = 0.87 - 0.93, rumination = 0.87- 0.91 magnification = 0.66 - 0.75, and helplessness = 0.78 - 0.87; [18; 23]). 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’ [19] (p.137). More broadly, there are concerns that many self-report measures used in health care, including pain, tend to be developed and used in an ad hoc way, without thorough validation and reliability testing across wide samples of participants [15] (p.34).

1. 3 Pain catastrophizing scores and personal characteristics

Studies have been conducted to explore potential differences in pain catastrophizing between people of different ages, genders, from different cultural backgrounds, and with different pain diagnoses. Such information helps to explain the extent to which the construct of pain catastrophizing can be viewed as stable across populations. Women tend to score higher than men [4; 12; 23; 26; 27], although one study reported no sex difference [22]. Older adults tend to score lower than younger adults [11; 24] but the effect is reversed in adolescents, where older adolescents score higher than younger [1]. Although a number of studies have reported pain catastrophizing scores for participants with different pain diagnoses (including many studies in this review), no review or commentary has compared or combined these.

There have been no studies of the difference in pain catastrophizing scores of participants using different language versions of the PCS or other measures of pain catastrophizing. Any disparity in PCS scores of participants using different language versions could be due to translations of the outcome measure or to cultural differences in the experience and expression of pain catastrophizing. Existing studies report higher levels of pain catastrophizing in Chinese Canadians compared to European Canadians [9] and in African-Americans compared to white Americans [4] using the same language scale. Therefore some limited evidence from healthy participants suggests the presence of cultural factors in mediating pain catastrophizing scores.

The rather inconsistent findings from studies on specific participant groups leave open the question of whether there are systematic age, sex, or other demographic differences in pain catastrophizing; no comprehensive investigation of such differences in pain catastrophizing has been attempted.

1.4 Aims of this review

The aims of this review were to systematically obtain data on PCS scores from a wide range of studies and first to explore the psychometric properties of the PCS using meta-analytic methods, then to investigate whether there were any clear differences in PCS scores according to personal characteristics of participants. The review also served to test the use of meta-analysis to investigate psychometric properties of self-report instruments widely used in psychological treatment.

1. Methods

1.1 Protocol and registration

The research protocol for the review and meta-analysis was registered on PROSPERO (prospective register of systematic reviews) at the University of York's Centre for Reviews and Dissemination (CRD), registration number CRD42016032863.

1.2 Eligibility criteria

English language studies reporting baseline PCS scores (those collected before any intervention) were included in the meta-analysis. Participants in those studies had to be aged 18 or over, could have any health condition or none, and both randomized and non-randomized studies were included. Included studies were those that reported demographic and clinical information about participants (age, sex, diagnostic category) and psychometric data for PCS scores (mean, standard deviation, sample size).

1.3 Search strategy

The search strategy was adapted for Cochrane Library, Cinahl, Embase, PsycInfo, PubMed, and Web of Science (all 1995-present) by using wildcards and terms relevant to each database (an example search strategy is included in **Suppl. Fig. 1**). The last search was run on 30 November 2015. Requests were sent to authors for data missing from otherwise relevant studies, resulting in eight responses with eligible scores to 81 requests for missing PCS data; and no eligible scores for 21 requests sent for missing demographic data.

1.4 Study selection and data collection

One reviewer (CW) screened the title and abstract of the studies retrieved in the database searches. A random sample (using a random number sequence generator) of 5% of the papers were screened by title and abstract by a second reviewer (SM) and the inter-rater reliability calculated. Discrepancies were discussed and resolved. The data collection form was adjusted following the pilot to allow for pooled data from studies that reported only PCS subscores, or scores from subgroups but personal data from the whole sample. Data items extracted from data including participant characteristics, study data, and study type are presented in **Suppl. Table 1**.

1.5 Risk of bias in individual studies

A component approach was used to assess the risk of bias in each included study [14]. Relevant components from the Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies [16] were used in this review and meta-analysis:

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?

Sensitivity analysis was conducted to ascertain the impact of bias from the above components on the overall effect sizes found in the meta-analysis. Meta-analysis of effect size was conducted first for all studies, and then repeated only for studies known to be eligible (meeting all three risk of bias criteria), following the Cochrane method [7]. There was unlikely to be a high risk of publication bias in the included data~~,~~ so no risk of bias analysis across studies was undertaken.

1.6 Meta-analysis to explore the psychometric properties of the PCS

2.6.1 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. Weights were based on the standard error for each sample. 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.

2.6.2 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.

2.6.3 Subgroup analysis

Wilson's macros for SPSS [29] were used to conduct Hedges-Olkin random effects meta-analysis [5] on participants grouped by pain diagnosis. 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. Hedges and Olkin's method uses a pooled variance estimate to standardize the difference between group means. Biases were corrected based on a sample size statistic using weighted scores.

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 standardized sum of squared differences between each effect size and the mean effect size:

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

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

2.6.4 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' [7] (9.5.2).

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

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

I^2 is reported as a percentage, where over 75% indicates substantial heterogeneity between trials [8].

2.6.5 Use of multiple regression to explore heterogeneity of PCS scores

SPSS version 23 [10] was used to conduct random-effects meta-analysis and meta-regressions. Multivariate meta-regression was conducted to explore the heterogeneity of mean PCS scores across participant groups by testing their association with variables and other study features.

Wilson's macro for SPSS was used to employ Hedges and Olkin's psychometric meta-analysis method, with results transformed from Fisher's z scores back to r scores after the analysis. This method of meta-regression uses a weighted least squares (WLS) procedure and scores from each study that are weighted by the inverse of the study's sampling error bias. 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 categorized into ranges of three years), study type, and language of PCS used. A further meta-regression was then run using pain category as the only variable. Re-running the meta-regression with this clinically relevant variable 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.

2. Results

3.1 Study selection

220 studies were identified for inclusion in the review and meta-analysis (see **Fig. 1** for searching and screening process). **Suppl. Table 2** provides details of reasons for the exclusion of studies.

[Insert Fig. 1 here] Flow diagram showing the searching and screening stages of papers to be included in the review and meta-analysis.

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 0.87 (accounting for agreement due to chance), meeting criteria for reliable inter-rater agreement [3] (p.56). Discrepancies were discussed and resolved between the raters, with a conservative approach followed in order to allow for further screening at a later stage.

3.2 Data cleaning and preparation

Data cleaning was conducted to remove double-counted data and data with errors (two papers in total). Seven further papers contained surprisingly low PCS scores but no evidence of the source of error; these papers were not removed from the analysis. Instead, meta-analytic methods were applied to correct for artifacts and error.

3.3 Study characteristics

Data from 220 studies published between 1997 and 2015 was included in the initial analyses. Included studies were cross sectional, psychometric, case series, randomized controlled and non-randomized controlled trials, case controlled, and cohort studies. Sample sizes ranged from 3 to 1,786, and many studies reported PCS scores and related data for two or more groups of participants so data were collected for 329 groups altogether. The PCS was represented by 21 languages translated from English.

Mean ages of participants in studies ranged from 19 to 76, with a grand mean age of 45 years, sd = 12 (for both weighted by sample size and unweighted). The grand total number of participants across included studies was 42,976. The gender ratio was 55:32:13 for male, female, and participants whose gender was not reported.

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). Unless otherwise stated, 'PCS score' refers to the total scale score. Subscale scores are reported where available. Results of individual studies are presented in **Suppl. Table 1** due to the large number of studies (220) and larger number of participant groups in the studies (*k* = 339).

3.4 Risk of bias analysis

Three screening questions were used to assess the risk of bias within studies:

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?

70 studies fulfilled criteria for all three screening questions. 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. Subgroup analysis determined 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 1**.

[Insert Table 1 here]

Regression analysis showed the PCS score to be significantly related to whether or not a study met all risk of bias criteria, 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, $p < .05$.

3.5 Meta-analysis to explore the psychometric properties of the PCS

3.5.1 Heterogeneity of the grand mean PCS score

The I^2 value of the grand mean PCS score is 98.96%, representing very substantial heterogeneity between studies. 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 (see section 3.5.4).

3.5.2 Reliability

Estimates of the internal consistency of the PCS full scale and subscales were based on Cronbach's coefficient alpha[2]. After weighting and averaging reports from 40 studies, the full scale alpha = 0.92 (95% CI 0.91 - 0.93). PCS subscale data was reported in 21 studies, with average internal consistency of alpha = 0.89 (95% CI = 0.87 - 0.91) for the rumination subscale; alpha = 0.77 (95% CI = 0.73 – 0.82) for the magnification subscale; and alpha = 0.88 (95% CI = 0.86 – 0.9) for the helplessness subscale.

Six studies provided eight samples (n = 317) that, when weighted and combined, produced a mean test-retest reliability of 0.88 (95% CI 0.83 - 0.93, range 0.73 – 0.97), representing good reliability. The time lapse between the test and retest in included samples ranged from 7 to 135 days. It was not possible to test reliability of scores by time lapse as a number of studies had a range of intervals between tests rather than a standardized interval (including one study in which the time lapse ranged between 14-135 days).

3.5.3 Analysis of heterogeneity of PCS scores across participant groups

Participants from studies included in this meta-analysis were categorized based on their pain diagnosis. The ‘other’ group consisted of diagnoses that did not fit into one of the specified categories, including participants with mixed pain diagnoses; these were excluded from analysis of heterogeneity. The wide spread between branches in the plot of weighted mean PCS scores suggests substantial heterogeneity in the PCS scores across participant groups (**Fig. 2**). Notably, participants with lower limb pain experienced, on average, lower pain catastrophizing than healthy participants by two points out of a possible score of 52 on the PCS, and the mean PCS scores of participants with upper limb or upper and lower limb pain were equivalent to those of healthy participants.

[Insert Fig. 2 here] Forest plot showing the weighted mean ES and confidence intervals of PCS scores for groups of participants based on pain diagnosis.

3.5.4 Subgroup analysis

Owing to the extent of heterogeneity between PCS scores of participants with different pain diagnoses, subgroup analysis was conducted to establish the heterogeneity of scores within diagnoses, to distinguish it from sampling error [6] (**Table 2**). I^2 values ranged from 92.27% to 99.04%, indicating high levels of heterogeneity *within* diagnostic groups; 193 groups (24,546 participants) fell into ‘other’/healthy/groups with mixed or unclear diagnoses and were excluded from this analysis.

Subgroup analysis between study types showed considerable overlap and homogeneity in mean PCS scores, with the exception of non-randomized controlled trials which had a higher mean PCS score than the grand total PCS score (27.55, 95% CI 24.15 - 30.95 compared to 20.22, 95% CI 19.44 - 21). This may be an artifact of data coming from two groups within one study which recruited participants only if they ‘reported high levels of pain catastrophizing’ [21] (p.859),

[insert Table 2 here]

3.5.5 Meta-regression of PCS scores

Multivariate meta-regression analysis was conducted to establish the association between PCS scores and characteristics of study participants (age, sex, diagnostic category) and study design (language of PCS, type of study, year of study publication). After exclusion because of missing data 277 groups were included in the analysis. Diagnostic category of participants, language, and type of study were all significantly associated with the mean PCS score obtained (**Table 3**). In a further meta-regression conducted with the variable of diagnostic category, this variable was again significantly associated with the mean PCS score (all 329 participant groups were included in this analysis; **see Table 4**).

[insert Tables 3 and 4 here]

Significantly higher or lower mean scores occurred for some non-English language versions of the PCS, notably for the Cantonese version of the PCS (weighted mean score for Cantonese was 36.3, compared to a mean of 18.48 for English versions, β 15.31, $p = .002$). The Cantonese scores were based on one study using the Cantonese language version.

3. Discussion

4.1 Psychometric properties of the PCS

The review included 220 studies of a total of 329 participant groups (42,976 clinical and non-clinical participants) with a mixture of pain diagnoses, age, and gender distributions, with a range of study types. Systematic review and meta-analytic methods were used to synthesize existing data by establishing and refining the known psychometric properties of the PCS using a far larger data set than previous studies. Internal consistency and test-retest reliability of the overall score and of the rumination subscale (but not of magnification or helplessness subscales), were all >0.85, encouraging confidence in use (see also Sullivan and colleagues [23]). The higher test-retest reliability found in this meta-analysis than previously [23] could be explained by shorter intervals between testing, or the inclusion in the current meta-analysis of stabler non-clinical samples alongside clinical samples. The psychometric findings on the PCS from a much larger evidence base may in part allay concerns over the 'ad-hoc' creation of psychometric self-report scales in health and psychology [15].

4.2 The relationship between PCS scores and participant characteristics

Subgroup analysis showed that PCS scores did not differ systematically with age or gender, again encouraging confidence in use,,particularly in the light of contradictory results of previous studies [1; 4; 11; 12; 22; 23; 24; 26; 27]. However, different pain diagnoses were associated with differences in PCS scores, and while this could be mediated by the association of pain catastrophizing scores with pain intensity reports [20], it is more likely that different pain problems are associated with different specific worries, and those with diagnoses that are difficult to establish or contested (such as fibromyalgia [31]) may more consistently generate catastrophic thinking. This requires further investigation.

The findings of this review reveal differences in PCS scores across populations and languages, but given the complexity of cultural and linguistic translation, it would be premature to try to interpret these findings. They do, however, serve as a reminder that simply translating a questionnaire does not guarantee that its psychometric properties remain the same as in the original language.

4.3 Strengths and limitations of the review

Strengths and limitations of this review are considered within a broader synthesis of the use of meta-analysis to establish psychometric properties of a self-report scale. Studies were included in this review if PCS use was reported in the study abstract, so it is likely that some studies were missed that only identified PCS use in their Methods. A replication could search all papers likely to be potentially eligible; this would likely be over 3000 papers. However, for this review, maximum use of included studies was made by including all data available per analysis. Additionally, the principle of assessing rather than selecting against methodological deficiency allowed the inclusion of all studies regardless of risk of bias, examined instead by sensitivity analysis and by weighting scores using a random effects model in the meta-analysis.

In this review, participants were categorized according to a single pain diagnosis, but many people with chronic pain have more than one pain condition, and could not be fitted into a pain diagnosis category. Studies used different ways of categorizing pain or describing pain diagnoses, meaning that data were matched to 'best fit' for this meta-analysis, for example 'low back pain', 'acute low back pain', 'chronic low back pain', and 'persistent non-specific low back pain' were classified as 'lumbar pain' although there may have been differences in diagnosis and threshold for classification in the different studies. The high proportion of 'healthy' participants in included studies who were students limits the generalizability of the results to the general population of ‘healthy’ people without a pain diagnosis but with a wider age range. This is not unique to this review.

It is possible that the decision to include other language versions of the PCS introduced biases and inaccuracies owing to different psychometric properties of these versions. The decision was justified by the widespread international use of the PCS, highlighting the need for further validation studies of the translated versions of the questionnaire.

The risk of bias screening was completed by one author (CW). Optimally, a second author would duplicate the screening and results would be compared. Otherwise, established protocols for systematic review and meta-analysis were followed [14]. Meta-analytic methods were used to correct for measurement artifacts within included studies by weighting scores to obtain more accurate estimated effect sizes.

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

Even excellent reliability does not imply validity of the concepts, and there are theoretical concerns about notions such as ‘magnification’ that imply contrast with a ‘correct’ amount of pain experience that are inconsistent with current understanding of pain psychology. Conclusions drawn in this review about psychometric properties of the PCS cannot be used as proof of validity of the concept of pain catastrophizing.

Overall, this review demonstrates a comprehensive attempt to identify relevant papers and a systematic method of discussing and deciding on inclusion and exclusion of studies. The use of meta-analysis across a large sample of studies allowed for exploration of narrow variance of PCS scores. The findings provide greater support for evidence from previous individual studies on the reliability and validity of the PCS.

4.4 Implications for clinical practice and research

Studies in this meta-analysis highlighted that the PCS is widely used 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 [23] (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 catastrophizing be based on percentiles across pain diagnoses, or is it more pertinent to establish a cut-off using comparisons with others 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. Further research is necessary to establish percentile PCS scores either across or within pain conditions using raw scores from multiple studies.

Changes from baseline PCS scores following treatment such as surgery or psychological therapy were not considered in the scope of this review. However, the more precise estimates provided here for internal consistency and test-retest reliability allows calculation of reliable change beyond that attributable to random variation across time. Meta-regression following systematic review helped to refine participant variables that did (language; pain diagnosis) and did not (age; gender) relate to PCS scores over a wide population. This helps to define variables of interest for future studies of the PCS and pain catastrophizing.

Finally, the methods used in this meta-analysis could be applied to any self-report scale (PROM) 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 in order better to understand sources of variance. This would strengthen the use of those self-report scales, as well as encouraging discarding those that fail standards of reliability and validity. Such research could help to introduce greater precision and theoretical justification to the ever-increasing aggregation of concepts and scales.

4. Conclusion

This is the first psychometric meta-analysis of the PCS, and the first investigation of the PCS on such a large scale. Meta-analytic methods in this review confirmed the reliability of the overall scale and refined psychometric and normative properties. The PCS as a full scale is concluded to be a reliable measure. Caution is urged in the clinical interpretation of scores due to differences in scores between people with different pain diagnoses, and potential linguistic or cultural influences on PCS scores should be considered when using different language versions of the scale. It is hoped that results from this review will encourage the use of meta-analytic methods to establish more accurate psychometric properties of other psychological and self-report scales.

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Conflicts of interest

The authors have nothing to disclose.

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Fig 1

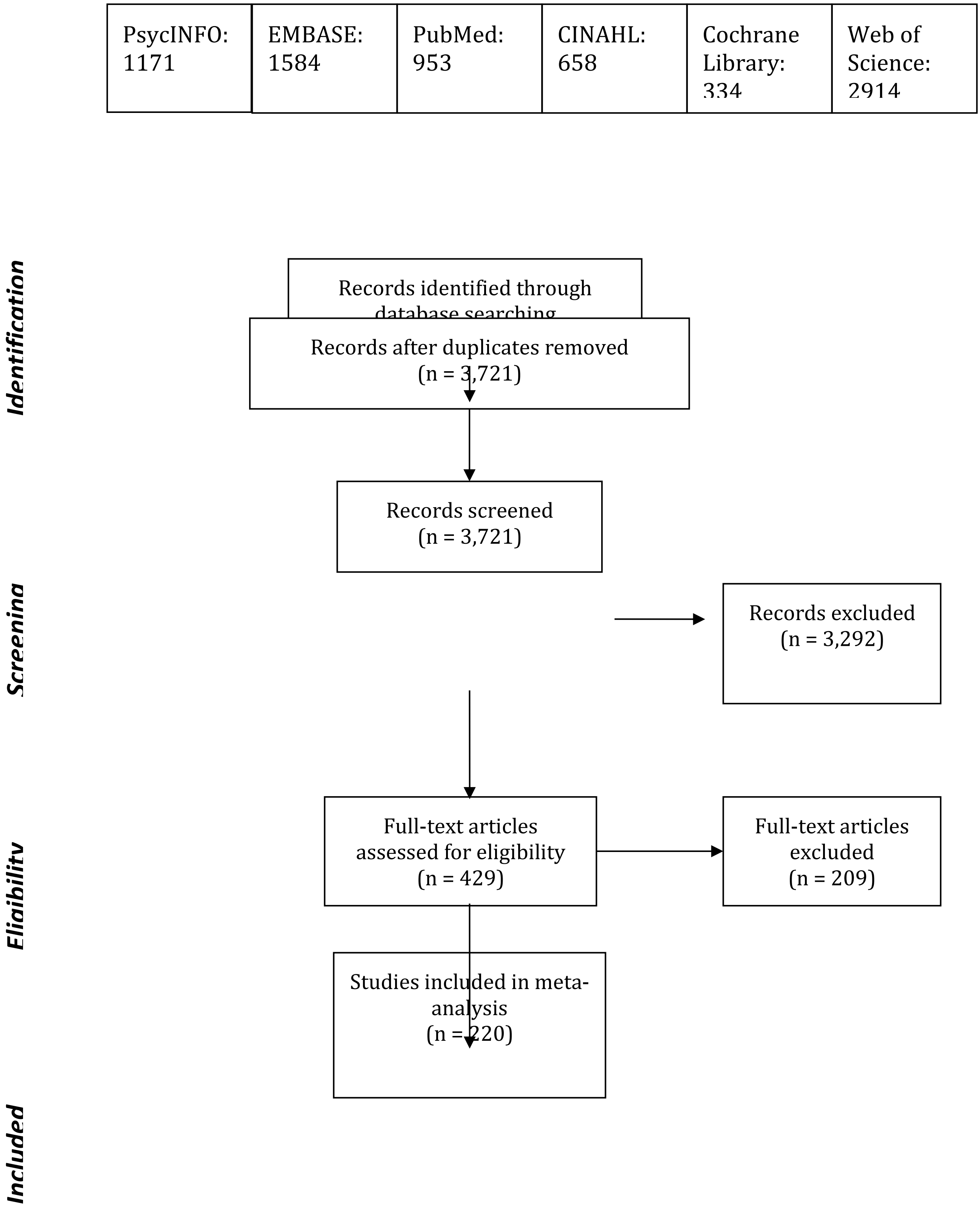
PsycINFO: 1171
EMBASE: 1584
PubMed: 953
CINAHL: 658
Cochrane Library: 334
Web of Science: 2914
Identification
Records identified through database searching
Records after duplicates removed (n = 3,721)
Records screened (n = 3,721)
Screening
Records excluded (n = 3,292)
Eligibility
Full-text articles assessed for eligibility (n = 429)
Full-text articles excluded (n = 209)
Studies included in meta-analysis (n = 220)
Included

Table 1. Weighted mean PCS scores and confidence intervals for all studies included in the meta-analysis, 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 of mean**	**Weighted sd of PCS score**	**95% CI of sd**
All studies	220	20.2	19.3-21.1	10.3	10.0-10.5
Studies meeting all risk of bias criteria	70	22.8	20.9-24.6	10.8	10.4-11.2
Studies not meeting all risk of bias criteria	150	19.1	18.2-20.1	10.0	9.7-10.3

Table 3. Association between covariates in meta-regression and the grand mean PCS score.

Variable	**Type III sum of squares**	**Degrees of freedom**	**Mean square**	**F**	**Significance level**	**Amount of variance accounted for (eta squared)**
Mean age of participants	118.00	1	118.00	3.15	.077	0.01
Percentage of female participants	31.52	1	31.52	0.84	.360	0.00
Diagnostic category of participants	5644.69	8	705.59	18.83	<.001	0.39
Language of PCS administered	3870.13	19	203.69	5.44	<.001	0.30
Type of study	1586.30	7	226.61	6.05	<.001	0.15
Year range of publication*	299.21	4	74.80	2.00	.096	0.03

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

Table 4. Regression of variable ‘diagnostic category of participants’ 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		17.24	14.41	20.07	11.99	<.001
Head and neck pain		6.70	2.61	10.80	3.22	.001
Cervical and thoracic pain		6.16	0.56	11.76	2.16	.031
Upper limbs or upper and lower limb pain		-3.40	-6.23	-0.57	-3.36	.019
Trunk pain		11.26	6.42	16.10	4.58	<.001
Lumbar pain		6.96	4.74	9.17	6.18	<.001
Lower limbs		-2.16	-6.33	2.01	-1.01	.309

Other or mixed diagnosis	8.25	6.44	10.07	8.94	<.001

Supplementary files

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

Suppl. Figure 1. Search strategy used to identify potentially relevant studies from the Cochrane Library.

Suppl. Table 1. Characteristics of studies included in the review and meta-analysis.

Study ID	First 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 6th yr medical students	53	24	1.8	10:43	16.8	9.9
19	Maric	2011	Cross	Croatian	Healthy participants 1st yr medical students	137	19	1.7	47:90	19.2	7.9

19	Maric	2011	Cross	Croatian	Healthy participants 1st yr economics students	245	19	1.7	86:159	19.7	9.1
19	Maric	2011	Cross	Croatian	Healthy participants 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, geriatric patients, older	78	67	5.6	28:50	25.6	13.7
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, college students	62	/	/	24:38	15.9	8.2
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 pain	192	46	13.1	60:132	23.9	8.9
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 stenosis, experimental group	65	59	11.8	21:44	24.8	9.3
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, young adults, men	12	/	/	12:0	5.2	4.1
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 with no HIV-associated sensory polyneuropathy	38	48	8.9	32:6	14.1	11.8
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	110	47	12.5	30:80	31.9	10.3

					post traumatic stress symtoms						
356	Ruscheweyh	2011	Cross	German	Healthy participants, younger group	88	27	4.8	29:59	15.5	8.8
356	Ruscheweyh	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 disability	42	41	12.9	25:17	15.8	4
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, university local community	48	22	4.4	12:36	14.2	7.8
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

Suppl. 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)
	12	Animal study

	10	Conference proceedings/posters
	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