Do Psychological Factors relate to Movement-Evoked Pain in People with Musculoskeletal Pain? A Systematic Review and Meta-Analysis

Running title: Do Psychological Factors relate to Movement-Evoked Pain?

Lynn Leemans,[a,b] Jo Nijs,[b,c,d] Luna Antonis,[a,b] Timothy H. Wideman,[e] Hester den Bandt,[b,f] Zoe Franklin,[g] Patrick Mullie,[h,I] Maarten Moens,[j,k,l] Erika Joos,[m] David Beckwée,[a,n,o]

[a] Rehabilitation Research Department, Vrije Universiteit Brussel, Brussels, Belgium

[b] Pain in Motion International Research Group, Department of Physical Therapy, Human Physiology and Anatomy, Faculty of Physical Education and Physical Therapy, Vrije Universiteit Brussel, Brussels, Belgium

[c] Department of Physical Medicine and Physical Therapy, University Hospital Brussels, Belgium

[d] Institute of Neuroscience and Physiology, University of Gothenburg, Gothenburg, Sweden

[e] School of Physical and Occupational Therapy, McGill University, Canada

[f] Department of Physical Therapy, University of Applied Sciences Rotterdam, Rotterdam, the Netherlands

[g] Department of Sport and Exercise Sciences, Centre for Musculoskeletal Science and Sports Medicine, Manchester Metropolitan University, Manchester, United Kingdom

[h] Department of Movement and Sport Sciences, Faculty of Physical Education and Physical Therapy, Vrije Universiteit Brussel, Brussels, Belgium

[i] Belgian Defense, COS Well-Being, Queen Elisabeth Barracks, Evere, Belgium

[j] Department of Neurosurgery, Universitair Ziekenhuis Brussel, Brussels, Belgium

[k] Department of Radiology, Universitair Ziekenhuis Brussel, Brussels, Belgium

[l] Center for Neurosciences (C4N), Vrije Universiteit Brussel, Brussels, Belgium

[m] Physical Medicine & Rehabilitation Department, UZ Brussel, Brussels, Belgium

[n] Frailty in Ageing Research Department, Vrije Universiteit Brussel, Brussels, Belgium

[o] Department Rehabilitation Sciences and Physical Therapy | Research Group MOVANT, Faculty of Medicine and Health Sciences, University of Antwerp, Belgium.

Corresponding author: Lynn Leemans, Rehabilitation Research Department and Pain in Motion International Research Group, Vrije Universiteit Brussel, Laarbeeklaan 103, B-1090 Brussels, Belgium; E-mail: Lynn.Leemans@vub.be

Abstract

Background: A growing body of evidence has demonstrated the importance of implementing movement-evoked pain in conventional pain assessments, with a significant role for psychological factors being suggested. Whether or not to include these factors in the assessment of movement-evoked pain has not yet been determined.

Objectives: The aim of this systematic review is to explore the association between psychological factors and movement-evoked pain scores in people with musculoskeletal pain.

Methods: For this systematic review with meta-analysis, four electronic databases (PubMed, Medline, WOS, and Scopus) were searched. Cross-sectional studies, longitudinal cohort studies, and randomized controlled trials investigating the association between movement-evoked pain and psychological factors in adults with musculoskeletal pain were considered. Meta-analysis was conducted for outcomes with homogeneous data from at least 2 studies. Fischer-Z transformations were used as the measure of effect. Quality of evidence was assessed using the National Institutes of Health's Quality assessment tool for observational cohort and cross-sectional studies and Grading of Recommendations Assessment, Development and Evaluation (GRADE) framework.

Results: Meta-analyses and grading the quality of evidence revealed moderate evidence for a relation between movement-evoked pain and depressive symptoms (Fisher-z=0.27; 95%CI: 0.17, 0.36; 5 studies (n=440)), pain-related fear (Fisher-z=0.35; 95%CI: 0.26, 0.44; 6 studies (n=492)), and pain catastrophizing (Fisher-z=0.47; 95%CI: 0.36, 0.58; 4 studies (n=312)) in people with musculoskeletal pain.

Conclusions: Movement-evoked pain is weakly to moderately associated to depressive symptoms, pain-related fear, and pain catastrophizing in people with musculoskeletal pain.

Keywords: Meta-analysis; movement-evoked pain, musculoskeletal pain, psychological factors, systematic review.

Highlights

- Movement-evoked pain is associated with depressive symptoms, pain-related fear, and pain catastrophizing
- Questionnaires on psychological factors should be included in MEP assessments.
- Cautious interpretation of these results regarding causality is warranted.

Introduction

Persistent musculoskeletal pain is the most common type of chronic pain.[1,2] It interferences with people's quality of life and is the global leader in disability.[3] Movement-evoked pain (MEP) is a frequently reported complaint amongst people with musculoskeletal pain[4,5] and a construct that provides unique information compared to pain at rest.[5,6] MEP accounts for a significant amount of variance in self-reported disability[7,8] and findings from Dailey et al.[9] suggest that transcutaneous electrical nerve stimulation reduces MEP – but not pain at rest – in individuals with fibromyalgia. In the literature, two types of outcome measures are used to evaluate MEP: a maximum or average pain score; representing the pain experienced by patients during a specific movement task, and an index score; representing a maximum or average pain score, yet corrected for baseline pain (i.e., to calculate the MEP index score, the baseline pain score – assessed at rest, before completing any movement task – is subtracted from the maximum (or average) pain score).[10-14] These two concepts thus capture a different experience, which may be an issue in reviews that combine all these measures in one analysis.[15,16] The mechanisms behind MEP in patients with musculoskeletal pain remain partly unknown. It is, however, speculated that aside from peripheral mechanisms, centrally-driven mechanisms are involved.

Evidence supporting these speculated central contributions is provided by quantitative sensory testing measures of central pain processing in patients with musculoskeletal pain[14,17] and significantly contributing psychological factors.[18,19] Some of these psychological factors have been previously discussed in the literature,[20,21] for which inconsistent results regarding their relation to MEP have been found (potentially due to differences in population [i.e., healthy people, people undergoing surgery or people experiencing musculoskeletal pain],[15] as well as a lack of clear protocols to objectify MEP[15,16]). A greater understanding of how psychological factors relate to MEP may lead to enhanced assessment methods of this construct. Whether to implement psychological constructs in clinical testing procedures, and eventually in rehabilitation programs, has not yet been determined.

Given that MEP appears to be a significant barrier in activity-based interventions,[22,23] and the positive association between psychological factors (i.e., pain-related beliefs) and improved functional outcomes,[24,25] filling this knowledge gap seems essential. According to our knowledge, no clear overview addressing the relation between MEP scores and psychological factors exists. Therefore, this systematic review aims to explore the association between psychological factors and MEP scores in patients with musculoskeletal pain.

Methods

Protocol & registration

This systematic review is reported consistent with the PRISMA guidelines.[26] The review protocol was a priori registered in the PROSPERO database (CRD42020181138).

Literature search

A systematic search was performed by screening PubMed, Web of Science, Scopus, and Medline until the 15th of April 2022. The search strategy was based on the PICO(S)-framework (Patient=individuals with musculoskeletal pain; Instrument of measurement=self-reported questionnaires; Comparison was not applicable; Outcomes=MEP scores and psychological factors; Study design=cross-sectional and cohort study designs, and randomized controlled trials). Search items are listed in the Supplementary Material. In addition, we performed a citation tracking using PubMed, and a reference search of the eligible studies.

Eligibility criteria – study selection

Studies needed to be cross-sectional studies, longitudinal cohort, or randomized controlled trials, and report the relationship between psychological factors and MEP scores in adults with musculoskeletal pain (a full electronic search strategy for PubMed is in the Supplementary Material). Studies were included if the title or abstract contained outcome measures reporting pain during any kind of movement task,[15] and intrinsic factors (situational, behavioral, and emotional) that cause patients to experience pain in a certain manner.[27,28] As MEP is expressed by the maximum or average pain score during a particular movement task, or by a MEP index score (i.e., maximum or average pain, corrected for baseline pain), the results were categorized accordingly. Numerical coding was used to indicate whether the article discussed the relation between psychological factors and MEP (coded as 1) or a MEP index (coded as 2), **Table 1**. After screening titles and abstracts, eligible articles were read in full. Two independent researchers (LL and LA) screened the title and abstract, and the full text using Rayyan software.[29] Disagreements were resolved by a consensus-based discussion.

Risk of bias

The methodological quality was rated as good, fair, or poor, using the National Institutes of Health's (NIH) Quality Assessment tool for observational cohort and cross-sectional studies,[30] and as low risk of bias, some concerns, or high risk of bias using the Revised Cochrane risk-of-bias tool for randomized trials.[31] The appraisal was independently performed by 2 blinded reviewers (LL and LA). Disagreements were resolved by a consensus-based discussion.

Summary measures and methods of analyses

All data regarding the associations between psychological factors and MEP were retrieved from the eligible papers. If the title or abstract included MEP and psychological factors as outcome measures, but no corresponding data were provided in the full-text article, authors were contacted. The mean correlation coefficient was calculated using Fischer-Z transformations as the measure of effect in the meta-analysis (MA). We interpreted .10 as a weak correlation, .30 as moderate, and .50 as a strong correlation.[32] Heterogeneity was assessed by the prediction interval (PI)[33] and by the I^2 statistic.[34] An I^2 value >50% was classified as important heterogeneity.[25] In this case, a subgroup analysis was conducted, investigating possible underlying differences that may explain heterogeneity. For the subgroup analyses, suggestions in the Cochrane Handbook that only a small number of characteristics – based on meta-analyses and clinical studies[8, 72, 78] – should be examined[26] were considered. If authors used multiple movement tasks to assess MEP, a sensitivity analysis was conducted.[26] We assessed confidence in the effect estimates using the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) approach.[35] There are four levels of quality, the highest initial rating being for randomized controlled trial evidence, and low-quality ratings for observational studies. We acknowledge, however, that not all observational studies are of low quality.[36] Therefore, the initial rating of "moderate" quality[37] could be downgraded to low, or very low quality evidence based on the following criteria: risk of bias, inconsistency (i.e., the presence of significant heterogeneity and inconsistent findings), indirectness (i.e., generalisability of the findings, the research does not address the intervention, population or outcomes of interest), imprecision (i.e., the total number of participants is less than the number of participants generated by a conventional sample size calculation for a single adequately powered study (i.e., less than 400 for continuous outcomes[38,39])), and publication bias (i.e., an under-estimation or over-estimation of the underlying effect due to selective publication of studies, e.g., inclusion of small studies, industry sponsored studies or asymmetrical funnel plots[40]). If performing a MA was not possible due to clinical or statistical heterogeneity (i.e., differences in assessment tool or questionnaire, or correlation coefficients could not be calculated based on given beta coefficients),[41,42] a best evidence synthesis (BES)[43] was performed.

Results

Study selection

The initial search of PubMed, Medline, WOS, and Scopus resulted in a total of 1897 hits, of which 1409 papers remained after deduplication. After screening papers on title and abstract, full text of 32 studies was examined in more detail. Finally, 23 suitable articles were included (**Figure 1**).

Study characteristics

Twenty-three studies were found eligible, of which six had an observational cohort study design and 21 a cross-sectional study design. A total sample of 2968 people with musculoskeletal pain was included. Characteristics of the included articles are presented in **Table 1.**

Risk of bias assessment

The percentage agreement between both reviewers was 87.4%. The methodological quality of the included studies is summarized in **Fig.2**. Weaknesses were lack of information on recruitment strategy and recruitment period. Also, adequate representation of the target population was mostly unclear and should be considered a potential bias in this review. Seventeen studies performed cross-sectional analyses. Therefore, questions 6 and 7 (i.e., exposure(s) measured and timeframe) of the NIH Quality Assessment tool[30] were answered as "no." In 4 studies performing (additional) regression analyses,[14,44-46] exposure was assessed prior to the outcome, yet during the same timeframe. In 2 studies, the authors spread the measurements by approximately 1 week.[13,47] Publication bias was not detected and is illustrated with funnel plots in the Supplementary Material.

Associations between psychological factors and MEP

Definitions of the included psychological factors can be found in Supplementary Material.

Anxiety. The relation between state anxiety and MEP was assessed in three studies[13,44,48]. In two studies[13,44], it was not possible to calculate the correlation coefficient based on the given data[42] and no

MA could be conducted. A BES[43] indicated limited evidence for a negative relation between state anxiety and MEP in patients with chronic low back pain (LBP), and limited evidence that state anxiety and MEP do not relate in patients with knee osteoarthritis (KOA).

*Depressive symptoms***.** Ten papers[10-13,48-53] investigated the association between depressive symptoms and MEP. Data from five studies (n=440) indicated a significant and small estimated mean correlation coefficient (Fisher-z(F_z)=0.27; 95%CI: 0.17, 0.36; PI:0.13, 0.40; I^2=0%, **Fig.3A**) in patients with musculoskeletal pain. The quality of evidence for this association estimate was moderate (**Table 2**). In five studies[13,48,50-52], no correlation coefficient was reported or could be calculated[42], and could not be included in the MA. Two studies[51,52] reported data consistent with the results of the MA.

Distress. Three studies[46,48,54] investigated the association between distress and MEP. Since only Hadlandsmyth et al.[48] reported correlation coefficients and the data reported by the two other studies[46,54] did not allow to calculate correlation coefficients[42], no MA was conducted. A BES[43] indicated conflicting evidence for a relation between distress and MEP in patients with KOA[48,54], and limited evidence for a positive relation in patients with musculoskeletal pain[46].

Pain-related fear. Seven studies [7,10-12,46,47,55] assessed the relation between pain-related fear and MEP. Data from six studies (n=492) indicated a significant and small estimated mean correlation coefficient (Fisher-z(F_z)=0.35; 95%CI: 0.26, 0.44; $p<0.001$; PI:0.22 to 0.47; I^2=0%, **Fig.3B**). The quality of evidence was moderate (**Table 2**). Damsgard et al.[46] could not be included in the MA as the data did not allow to calculate a correlation coefficient[42], and Crombez et al.[55] reported results based on Fear Avoidance Beliefs Questionnaire (FABQ) subscales. A BES[43] indicated limited evidence for a positive relation between MEP and the FABQ-work subscale score[55] in patients with LBP.

Pain catastrophizing. Six trials[10-13,47,51] investigated the relation between pain catastrophizing and MEP in patients with musculoskeletal pain. Data from four papers[10-12,47] (n=312) reported a moderate estimated mean correlation coefficient (Fisher-z(F_z)=0.47; 95%CI: 0.36, 0.58; PI:0.17, 0.69; I^2=0%,

Fig.3D). The quality of evidence for this correlation estimate was moderate (**Table 2**). Two studies[13,51] could not be included in the MA because no correlation coefficient was reported or could be calculated[42]. One study[51] reported data consistent with the results of the MA.

Pain hypervigilance. Cruz-Almeida et al.[51] assessed the relation between pain vigilance and MEP in patients with KOA. A BES[43] indicated limited evidence for an association between pain vigilance and MEP in patients with KOA.

Perceived injustice. Penn et al.[53] investigated the relation between perceived injustice and MEP in patients with chronic LBP. A BES[43] indicated limited evidence for a positive association between perceived injustice and MEP in patients with chronic LBP.

Positive and negative affect. Two studies[50,56] investigated the relation between positive and negative affect and MEP. However, only one study[56] reported a correlation coefficient and the data reported by Bartley et al. (a)[50] did not allow to calculate the correlation coefficient. Therefore, no MA could be conducted. A BES[43] indicated limited evidence that positive and negative affect and MEP are not associated in patients with KOA and chronic LBP. Two papers[51,57] assessed the association between positive affect and MEP in patients with KOA. However, only Wideman et al.[57] reported a correlation coefficient, and the data reported by Cruz-Almeida et al.[51] did not allow to calculate the correlation coefficient. Therefore, no MA could be conducted. A BES[43] indicated conflicting evidence for an association between positive affect and MEP in patients with KOA. Three studies[51,55,57] investigated the association between negative affect and MEP. Data from two papers[55,57] (n=146) reported a small estimated mean correlation coefficient (Fisher-z(F_z)=0.26; 95%CI: 0.09, 0.49; I^2=0%, **Fig.3C**). The quality of evidence for this association estimate was low (**Table 2**). One study[51] could not be included in this MA because the data did not allow to calculate the correlation coefficient, yet was consistent with the results of the MA.

Positive well-being. The relation between positive well-being and MEP was assessed in two studies.[50,56] However, only one study[56] reported a correlation coefficient and the data reported by Bartley et al. (a)[50] did not allow to calculate the correlation coefficient, so no MA could be conducted. A BES[43] indicated limited evidence for a small and negative association in patients with KOA, and limited evidence that positive well-being and MEP are not related in patients with chronic LBP.

Resilience and optimism. Three studies assessed the relation between resilience[47,50,56] and MEP in patients with KOA and LBP.[47,50] Because the data reported by Bartley et al. (a)[50] did not allow to calculate a correlation coefficient, and Palit et al. included *pain resilience* whereas Bartley et al. (b)[56] investigated *trait resilience*, no MA was conducted. A BES[43] indicated moderate evidence that resilience and MEP are not related in patients with LBP,[47,50] and limited evidence for a small and negative relation in patients with KOA.[56] Two studies reported the association between optimism and MEP in patients with KOA[56] and chronic LBP.[50] Because the data reported by Bartley et al. (a)[50] did not allow to calculate a correlation coefficient, no MA was conducted. A BES[43] indicated limited evidence for a negative relation between MEP and optimism in patients with KOA, and for no relation in patients with chronic LBP.

Self-efficacy. Two papers[46,58] reported the association between self-efficacy and MEP in patients with KOA[58] and musculoskeletal pain.[46] However, Adegoke et al.[58] reported correlation coefficients and the data reported by Damsgard et al.[46] did not allow to calculate the correlation coefficient. A BES[43] indicated limited evidence for a negative relation in patients with KOA and musculoskeletal pain.

Associations between psychological factors and MEP index scores

Chronic pain acceptance. Rabey et al.[59] investigated the association between chronic pain acceptance and MEP index scores in patients with chronic LBP. A BES[43] indicated limited evidence for a positive relation in patients with chronic LBP.

Depressive symptoms. Four studies[10-12,14] reported the relation between depressive symptoms and MEP index scores in patients with musculoskeletal pain. Data (n=359) indicated a small, but non-significant estimated mean correlation coefficient (Fisher-z(F_z)=-0.01; 95%CI: -0.14, 0.12; PI:-0.47, 0.45; I^2=35%, **Fig.3E**). The quality of evidence for this association estimate was moderate (**Table 2**).

Pain-related fear. Seven studies[7,10-12,45,59,60] assessed the relation between pain-related fear and MEP index scores in patients with chronic LBP. Data from five studies[7,10-12,45] (n=510) reported a small estimated mean correlation coefficient (Fisher-z(F_z)=0.14; 95%CI: 0.06, 0.23; PI:-0.01, 0.28; I^2=0%, **Fig.3F**). The quality of evidence for this correlation estimate was moderate (**Table 2**). Because La Touche et al.[60] classified the participants as “low” or “high self-efficacy groups,” this paper was not included in the MA yet reported data consistent with the results of the MA. Also, data reported by Rabey et al.[59] did not allow to calculate the correlation coefficient, and was therefore not included in the MA.

Pain catastrophizing. Five studies[10-12,14,45] assessed the association between pain catastrophizing and MEP index scores in patients with musculoskeletal pain. Data (n=475) indicated a small estimated mean correlation coefficient (Fisher-z(F_z)=0.17; 95%CI: 0.08, 0.26; PI:0.02, 0.31; I^2=0%, **Fig.3G**). The quality of evidence for this correlation estimate was moderate (**Table 2**). Because La Touche et al.[60] classified the participants as “low” or “high self-efficacy groups”, this paper was not included in the MA, yet reported consistent results.

Self-efficacy. One study[59] investigated the relation between self-efficacy and MEP index scores in patients with chronic LBP. A BES[43] indicated limited evidence for a negative relation in patients with chronic LBP.

Sensitivity analyses

Both Wideman et al.[57] and Woznowski-Vu et al.[45] used different movement tasks to assess MEP. Therefore, sensitivity analyses were conducted. To investigate the relation between MEP and negative affect in patients with KOA, Wideman et al.[57] used the timed up and go (TUG) and a 6-minute walk test to assess MEP. Sensitivity analyses showed different results by including different movement tasks. Including the TUG resulted in a small estimated mean correlation coefficient (Fisher-z=0.26; 95%CI: 0.09, 0.49; PI: 0.10, 0.41; I^2=0%). When the 6-minute walk test was included, this resulted in a large estimated mean correlation coefficient (Fisher-z=0.53; 95%CI: 0.37, 0.70, PI: 0.40, 0.64; I^2=76%). However, heterogeneity was high. Furthermore, to investigate how the MEP-index relates to pain-related fear and pain catastrophizing, Woznowski-Vu et al.[45] utilised three movement tasks (i.e., self-paced walk, standardized lift, tailored lift). However, sensitivity analyses did not result in different results.

Discussion

This systematic review and MA aimed to provide an overview of the association between MEP and psychological factors in patients with musculoskeletal pain. According to the GRADE-approach[35] (**Table 2**), there is moderate evidence for a weak relationship between MEP and depressive symptoms and pain-related fear in patients with musculoskeletal pain. There is also moderate evidence for a moderate relationship between MEP and pain catastrophizing in patients with musculoskeletal pain. Additionally, this review provided moderate evidence for a relationship between MEP index scores and pain-related fear and pain catastrophizing in patients with musculoskeletal pain. The results from the BES can be found in the Supplementary Material for both MEP and MEP index scores respectively.

The results of the current study indicate that MEP is associated with depressive symptoms, pain-related fear, and pain catastrophizing in patients with musculoskeletal pain. As the perception of pain is influenced by biological, psychological, and movement system factors, incorporating all contributing aspects during treatment seems warranted. Unfortunately, this review reports correlations, which prevents drawing specific hypotheses on causality and consequently does not provide an answer to the *contributing* aspect of psychological factors in MEP. Few studies included in this review reported longitudinal data and results using linear regression techniques[14,46,47]: pain-related fear significantly predicted MEP in patients with chronic musculoskeletal disorders[46] and pain catastrophizing significantly predicted MEP in patients with chronic LBP[47] and KOA.[14] In the management of (chronic) pain, a mechanism-based approach is suggested,[61] indicating that psychosocial approaches (e.g., pain education) tackling pain mechanisms and maladaptive psychological factors are recommended in subgroups where central mechanisms play a (significant) role. This subgroup with involvement of central mechanisms is often referred to as patients with a predominance of nociplastic pain.[62] The growing evidence that educating patients positively affects central pain processing (e.g., increased pain thresholds[63,64] and conditioned pain modulation[64,65]) creates an exciting window for MEP-rehabilitation.. We hope that this review will encourage researchers to gain insight into the role of pain education when addressing MEP in patients with musculoskeletal pain and, perhaps even more important, in patients with a predominance of nociplastic pain.

The relation between psychological factors and MEP is not always assessed identically. Some authors use an average/maximum activity-related pain score, while others include a MEP index score (i.e., maximum or average pain, corrected for baseline pain). This index is associated with elevated scores of clinical indices of hypersensitivity.[11,66] Because hypersensitivity is associated with psychological factors,[67-69] it is not surprising that the present study found a weak but significant association between MEP index scores and pain-related fear and pain catastrophizing in patients with musculoskeletal pain. Furthermore, analyzing studies including pain populations with a predominance of nociplastic pain[7,11] (such as fibromyalgia and chronic whiplash syndrome[61]) resulted in stronger correlation coefficients for depressive symptoms (Fisher-z(SE)=-0.20 (0.13)), pain catastrophizing (Fisher-z(SE)=0.29 (0.13)), and pain-related fear (Fisher-z(SE)=0.16 (0.13)) compared to the estimated mean correlation coefficients (**Table 2**). The presence of these associations supports the notion that MEP can be influenced by both peripheral and central mechanisms, and that the contribution of these central mechanisms seems to increase in populations with a predominance of nociplastic pain.

Limitations and strengths

The heterogeneity in terms of reported outcomes and statistical analysis methods prevents drawing firm conclusions. Also, due to the observational study designs, no conclusions could be drawn on the causality of the observed associations between MEP and psychological factors. It is not possible to differentiate whether psychological factors affect MEP or MEP affects psychological factors in patients with musculoskeletal pain. Future studies using multiple data points are needed to further clarify potential causality between both constructs.[70] Furthermore, the pain conditions represented in the BES are limited to KOA and (chronic) LBP. Despite these limitations, this review has several important strengths as well. A systematic and transparent methodology was implemented and a priori registered, incorporating the evaluation of internal (risk of bias) and external validity (given the broad range of musculoskeletal conditions included in this systematic review). In addition, we applied the GRADE framework to determine the overall quality of evidence. For studies that could not be included in a MA, qualitative analyses were performed according to the BES[43] principle.

Conclusions

MEP measures are weakly to moderately associated with depressive symptoms, pain-related fear, and pain catastrophizing in patients with musculoskeletal pain. Future research should investigate whether addressing these maladaptive psychological factors can help improve MEP.

Supplementary Material A. Search terms

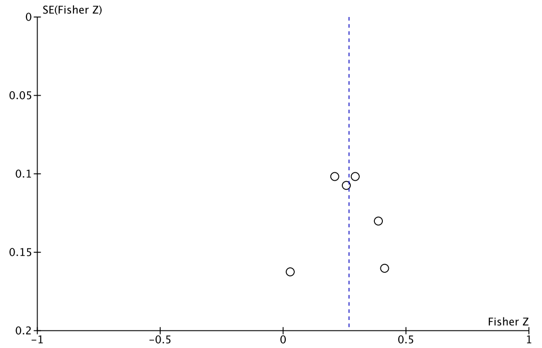
Movement-evoked pain		**Psychological factors**	
Movement-evoked pain	Mechanical pain	Anxiety	Pain awareness
Pain during movement	Nociceptive pain	Fear of pain	Pain perception
Pain with movement	Functional wind-up	Illness beliefs	Trait anxiety
Exercise-related pain	Activity-induced summation of pain	Pain-related stress	Kinesiophobia
Exercise-induced pain	Repetition-induced summation of pain	Fear of movement	Pain somatization
Movement-related pain	Sensitivity to physical activity	Pain catastrophizing	Pain-related fear
Activity-related pain		Depressive thoughts	Fear avoidance beliefs
Movement-induced pain		Self-efficacy	

Supplementary Material B. Full electronic search strategy for PubMed

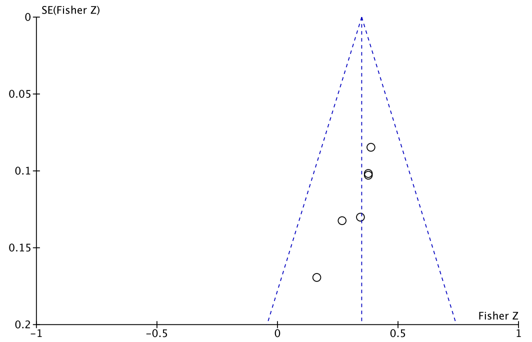
Search (((((((((("pain awareness") OR "fear of pain") OR "kinesiophobia") OR "illness beliefs") OR anxiety) OR "pain perception") OR "catastrophization") OR "fear of movement") OR ((((((((((((((((((((((((((((((((((("illness perceptions") OR "self-efficacy") OR "pain related stress") OR "pain beliefs") OR #5) OR "depressive thoughts") OR "stress") OR "frustration") OR "social isolation") OR "pain somatization") OR #11) OR "mindset") OR #13) OR "self-compassion") OR "pain catastrophizing") OR "personality types") OR #17) OR "defensive high-anxious") OR "low-anxious") OR "repressor") OR "non-extreme") OR "trait sensitivity") OR "big five personality types") OR "big five personality dimensions") OR #26) OR "big five personality traits") OR "extraversion") OR "agreeableness") OR "conscientiousness") OR "neuroticism") OR "openness") OR "trait sensory profiles") OR "sensory profiles") OR "trait anxiety") OR "trait characteristics"))) AND ((((((((((((((((((((("Nociceptive Pain"[Mesh]) OR "pain during movement") OR mechanical pain) OR "exercise related pain") OR "activity related pain") OR "pain movement evoked") OR "sensitivity to physical activity") OR "repetition induced summation of pain") OR "exercise-induced hypoalgesia") OR "hypoalgesia after exercise") OR "activity induced summation of pain") OR "movement related pain") OR "exercise related hyperalgesia") OR "functional wind-up") OR "pain-on-movement") OR "exercise induced pain") OR "pain evoked by movement") OR "movement-induced pain") OR "movement evoked pain")) OR nociceptive pain))

Supplementary Material C. Publication bias assessment

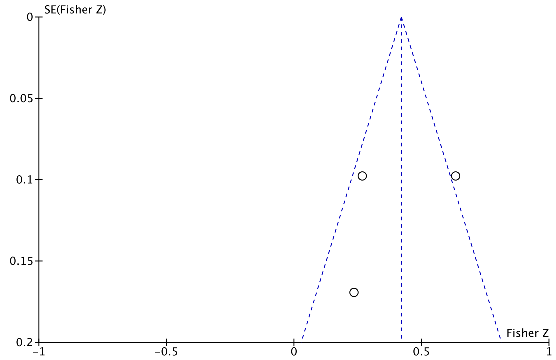
C.1. Funnel plot of the association between movement-evoked pain and depressive symptoms in patients with musculoskeletal pain



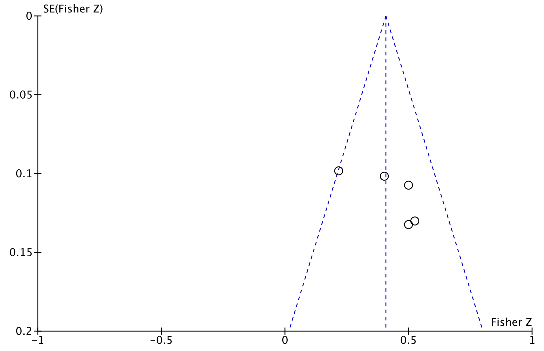
C.2. Funnel plot of the association between movement-evoked pain and pain-related fear in patients with musculoskeletal pain



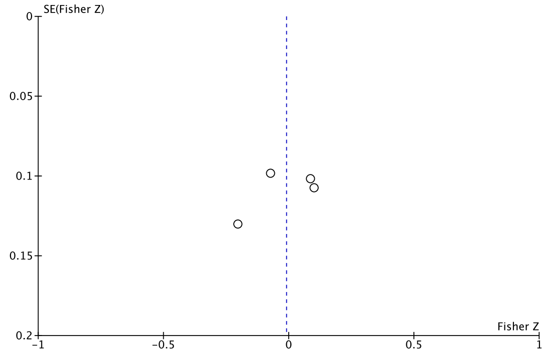
C.3. Funnel plot of the association between movement-evoked pain and negative affect in patients with musculoskeletal pain



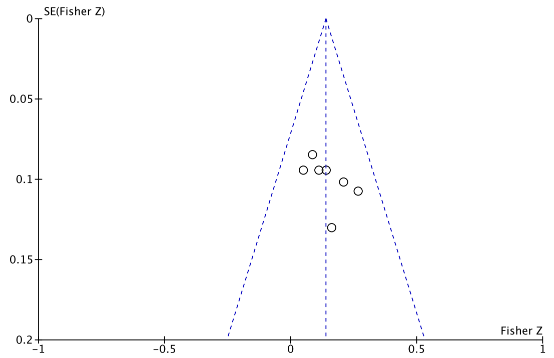
C.4. Funnel plot of the association between movement-evoked pain and pain catastrophizing in patients with musculoskeletal pain



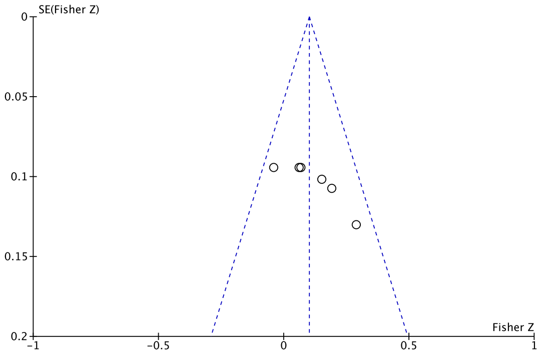
C.5. Funnel plot of the association between movement-evoked pain index scores and depressive symptoms in patients with musculoskeletal pain



C.6. Funnel plot of the association between movement-evoked pain index scores and pain-related fear in patients with musculoskeletal pain



C.7. Funnel plot of the association between movement-evoked pain index scores and pain catastrophizing in patients with musculoskeletal pain



Supplementary Material D. Definitions of psychological factors according to the included studies

Psychological factor	**Author (year)**	Definition
Anxiety	Tonelli (2011)	State anxiety reflects a transitory emotional state, while trait anxiety reflects relatively stable individual differences in anxiety.
Chronic pain acceptance	Rabey (2016)	A person's ability to have ongoing pain without attempting to avoid or control it.
Depressive symptoms	Penn (2020)	Symptoms of depression include negative mood, guilt/worthlessness, helplessness/hopelessness, psychomotor retardation, loss of appetite, and sleep disturbance.
Distress	Booker (2019)	An individual's perception of psychological stress.
	Hadlandsmyth (2017)	The amount of distress caused by pain or the affective impact pain severity.
Pain-related fear	Crombez (1999), Rabey (2016)	The fear of movement and re-injury due to movement.
	Lambin (2011), Sulivan (2009, 2010)	Fear of movement and re-injury associated with pain.
	Mankovsky-Arnold (2014)	Fear of movement and re-injury associated with their experience of pain.
	Palit (2019)	Fear of pain (including fear of re-injury or movement), which can subsequently lead to avoidance of engagement in activities and other stimuli seen as potentially leading to further injury.
	Woznowski-Vu (2019)	Fear-avoidance related beliefs about pain and physical activity.
Pain catastrophizing	Lambin (2011), Palit (2019), Sullivan (2009, 2010)	Catastrophic thinking related to pain.
	Rabey (2016)	A person's thoughts and feelings in terms of magnification, rumination, and helplessness about pain
	Woznowski-Vu (2019)	An exaggerated negative perception of pain.
Pain hypervigilance	Cruz-Almeida (2017)	Attention to pain, preoccupation and vigilance related to pain.
Perceived injustice	Penn (2020)	Cognitive appraisals reflecting the severity and irreparability of pain-related loss, externalized blame, and unfairness; perception of pain-related injustice.
Positive and negative affect	Bartley (2019b)	Underlying dimensions of a broad set of emotional states characterized by pleasant (i.e., interested, excited, strong, etc.) and unpleasant (i.e., distressed, upset, nervous, etc.) moods or emotions.
	Wideman (2016)	Discomfort and affect measures, including happiness, pleasantness, and calmness for positive affect and anxiety, tension, nervousness, and irritation for negative affect.
Positive well-being	Bartley (2019b)	Components of positive affect, life satisfaction, and an overall sense of purpose and meaning.
Resilience	Bartley (2019b)	The ability to bounce back and recover from stress.
	Palit (2019)	The perceived capacity to regulate thoughts and emotions and to maintain positive, adaptive functioning while in pain.
Self-efficacy	Adegoke (2017)	Beliefs concerning completion of tasks related to pain management and function.
	La Touche (2019)	A psychological state in which the individual judges their ability to perform an action or behavior in the most effective manner, considering the circumstances and the perceived difficulty level.
	Rabey (2016)	A person's beliefs regarding their ability to undertake activities despite pain.

Supplementary Material E. Summary table of best evidence syntheses assessing the association between psychological factors and movement-evoked pain.

Strength of evidence		**Population**	**Psychological factor**
Limited	Relation	Low back pain	Distress, perceived injustice, anxiety, self-efficacy
		Knee osteoarthritis	Resilience, positive wellbeing, optimism, pain hypervigilance, self-efficacy
	No relation	Low back pain	Positive and negative affect, optimism, and positive well-being.
		Knee osteoarthritis	Positive and negative affect, anxiety
Moderate	No relation	Low back pain	Resilience
Conflicting	Relation	Knee osteoarthritis	Distress

Supplementary Material F. Summary table of best evidence syntheses assessing the association between psychological factors and movement-evoked pain index scores.

Strength of evidence		**Population**	**Psychological factor**
Limited	Relation	Low back pain	Chronic pain acceptance, self-efficacy.

Acknowledgements: We wish to thank Dr Nicolas Delvaux and Dr Trudy Bekkering from the Belgian Centre for Evidence-Based Medicine for their help with the design and finalization the summary of findings tables. Funding for this study was obtained from the grant Wetenschappelijk Fonds Willy Gepts (WFWG) of the UZ Brussels.

Conflict of Interest: None

.

References

1. Schopflocher D, Taenzer P, Jovey R. The prevalence of chronic pain in Canada. *Pain Res Manag.* 2011;16(6):445-450.
2. Nakamura M, Nishiwaki Y, Ushida T, Toyama Y. Prevalence and characteristics of chronic musculoskeletal pain in Japan. *J Orthop Sci.* 2011;16(4):424-432.
3. Hoy D, March L, Brooks P, et al. The global burden of low back pain: estimates from the Global Burden of Disease 2010 study. *Annals of the rheumatic diseases.* 2014;73(6):968-974.
4. Graven-Nielsen T, Arendt-Nielsen L. Assessment of mechanisms in localized and widespread musculoskeletal pain. *Nature Reviews Rheumatology.* 2010;6(10):599.
5. Corbett DB, Simon CB, Manini TM, George SZ, Riley JL, 3rd, Fillingim RB. Movement-evoked pain: transforming the way we understand and measure pain. *Pain.* 2019;160(4):757-761.
6. Srikandarajah S, Gilron I. Systematic review of movement-evoked pain versus pain at rest in postsurgical clinical trials and meta-analyses: a fundamental distinction requiring standardized measurement. *Pain.* 2011;152(8):1734-1739.
7. Mankovsky-Arnold T, Wideman TH, Larivière C, Sullivan MJL. Measures of spontaneous and movement-evoked pain are associated with disability in patients with whiplash injuries. *Journal of Pain.* 2014;15(9):967-975.
8. Mankovsky-Arnold T, Wideman TH, Thibault P, Larivière C, Rainville P, Sullivan MJL. Sensitivity to Movement-Evoked Pain and Multi-Site Pain are Associated with Work-Disability Following Whiplash Injury: A Cross-Sectional Study. *J Occup Rehabil.* 2017;27(3):413-421.
9. Dailey DL, Rakel BA, Vance CG, et al. Transcutaneous electrical nerve stimulation reduces pain, fatigue and hyperalgesia while restoring central inhibition in primary fibromyalgia. *Pain.* 2013;154(11):2554-2562.
10. Sullivan MJ, Larivière C, Simmonds M. Activity-related summation of pain and functional disability in patients with whiplash injuries. *Pain.* 2010;151(2):440-446.
11. Sullivan MJ, Thibault P, Andrikonyte J, Butler H, Catchlove R, Lariviere C. Psychological influences on repetition-induced summation of activity-related pain in patients with chronic low back pain. *Pain.* 2009;141(1-2):70-78.
12. Lambin DI, Thibault P, Simmonds M, Lariviere C, Sullivan MJ. Repetition-induced activity-related summation of pain in patients with fibromyalgia. *Pain.* 2011;152(6):1424-1430.
13. Tonelli SM, Rakel BA, Cooper NA, Angstom WL, Sluka KA. Women with knee osteoarthritis have more pain and poorer function than men, but similar physical activity prior to total knee replacement. *Biology of sex differences.* 2011;2:12.
14. Wideman TH, Finan PH, Edwards RR, et al. Increased sensitivity to physical activity among individuals with knee osteoarthritis: relation to pain outcomes, psychological factors, and responses to quantitative sensory testing. *Pain.* 2014;155(4):703-711.
15. Fullwood D, Means S, Merriwether EN, Chimenti RL, Ahluwalia S, Booker SQ. Toward Understanding Movement-evoked Pain (MEP) and its Measurement: A Scoping Review. *Clin J Pain.* 2021;37(1):61-78.
16. Leemans L, Polli A, Nijs J, Wideman T, den Bandt H, Beckwee D. It Hurts to Move! Assessing and Treating Movement-Evoked Pain in Patients With Musculoskeletal Pain: A Systematic Review With Meta-analysis. *J Orthop Sports Phys Ther.* 2022:1-52.
17. Rakel B, Vance C, Zimmerman MB, Petsas-Blodgett N, Amendola A, Sluka KA. Mechanical hyperalgesia and reduced quality of life occur in people with mild knee osteoarthritis pain. *Clin J Pain.* 2015;31(4):315-322.
18. Waddell G, Newton M, Henderson I, Somerville D, Main CJ. A Fear-Avoidance Beliefs Questionnaire (FABQ) and the role of fear-avoidance beliefs in chronic low back pain and disability. *Pain.* 1993;52(2):157-168.
19. Vlaeyen JW, Linton SJ. Fear-avoidance and its consequences in chronic musculoskeletal pain: a state of the art. *Pain.* 2000;85(3):317-332.
20. Keefe FJ, Rumble ME, Scipio CD, Giordano LA, Perri LM. Psychological aspects of persistent pain: current state of the science. *J Pain.* 2004;5(4):195-211.
21. Turk DC, Fillingim RB, Ohrbach R, Patel KV. Assessment of Psychosocial and Functional Impact of Chronic Pain. *J Pain.* 2016;17(9 Suppl):T21-49.
22. Jack K, McLean SM, Moffett JK, Gardiner E. Barriers to treatment adherence in physiotherapy outpatient clinics: a systematic review. *Manual therapy.* 2010;15(3):220-228.

23. Joelsson M, Bernhardsson S, Larsson ME. Patients with chronic pain may need extra support when prescribed physical activity in primary care: a qualitative study. *Scandinavian journal of primary health care.* 2017;35(1):64-74.
24. Thibault P, Loisel P, Durand MJ, Catchlove R, Sullivan MJ. Psychological predictors of pain expression and activity intolerance in chronic pain patients. *Pain.* 2008;139(1):47-54.
25. Stroud MW, Thorn BE, Jensen MP, Boothby JL. The relation between pain beliefs, negative thoughts, and psychosocial functioning in chronic pain patients. *Pain.* 2000;84(2-3):347-352.
26. Liberati A, Altman DG, Tetzlaff J, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. *PLoS Med.* 2009;6(7):e1000100.
27. McGrath PA. Psychological aspects of pain perception. *Archives of oral biology.* 1994;39 Suppl:55S-62S.
28. Linton SJ, Shaw WS. Impact of psychological factors in the experience of pain. *Phys Ther.* 2011;91(5):700-711.
29. Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A. Rayyan-a web and mobile app for systematic reviews. *Systematic reviews.* 2016;5(1):210.
30. National Heart L, Institute B. Quality assessment tool for observational cohort and cross-sectional studies. *Bethesda: National Institutes of Health, Department of Health and Human Services.* 2014:103-111.
31. Sterne JAC, Savovic J, Page MJ, et al. RoB 2: a revised tool for assessing risk of bias in randomised trials. *BMJ (Clinical research ed).* 2019;366:l4898.
32. Cohen J. A power primer. *Psychol Bull.* 1992;112(1):155-159.
33. Borenstein M, Higgins JP, Hedges LV, Rothstein HR. Basics of meta-analysis: I(2) is not an absolute measure of heterogeneity. *Res Synth Methods.* 2017;8(1):5-18.
34. Higgins JP, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. *BMJ.* 2003;327(7414):557-560.
35. Ryan R, Hill, S. How to GRADE the quality of the evidence. *Cochrane Consum Commun Gr.* 2019:1-24.
36. Viswanathan M, Ansari MT, Berkman ND, et al. Assessing the Risk of Bias of Individual Studies in Systematic Reviews of Health Care Interventions. In: *Methods Guide for Effectiveness and Comparative Effectiveness Reviews.* Rockville (MD)2008.
37. Johnson PI, Koustas E, Vesterinen HM, et al. Application of the Navigation Guide systematic review methodology to the evidence for developmental and reproductive toxicity of triclosan. *Environ Int.* 2016;92-93:716-728.
38. Guyatt GH OA, Kunz R, Brozek J, Alonso-Coello P, Rind D, Devereaux PJ, Montori VM, Freyschuss B, Vist G, Jaeschke R, Williams JW Jr, Murad MH, Sinclair D, Falck-Ytter Y, Meerpohl J, Whittington C, Thorlund K, Andrews J, Schünemann HJ. . GRADE guidelines 6. Rating the quality of evidence--imprecision. *J Clin Epidemiol* 2011;64(2011 Dec):1283-1293.
39. Case LD, Ambrosius WT. Power and sample size. *Methods in molecular biology (Clifton, NJ).* 2007;404:377-408.
40. Guyatt GH, Oxman AD, Montori V, et al. GRADE guidelines: 5. Rating the quality of evidence--publication bias. *J Clin Epidemiol.* 2011;64(12):1277-1282.
41. Gagnier JJ, Moher D, Boon H, Beyene J, Bombardier C. Investigating clinical heterogeneity in systematic reviews: a methodologic review of guidance in the literature. *BMC Med Res Methodol.* 2012;12:111.
42. Peterson RA, Brown SP. On the use of beta coefficients in meta-analysis. *J Appl Psychol.* 2005;90(1):175-181.
43. van Tulder M, Furlan A, Bombardier C, Bouter L, Editorial Board of the Cochrane Collaboration Back Review G. Updated method guidelines for systematic reviews in the cochrane collaboration back review group. *Spine (Phila Pa 1976).* 2003;28(12):1290-1299.
44. Murphy D, Lindsay S, Williams AC. Chronic low back pain: predictions of pain and relationship to anxiety and avoidance. *Behaviour research and therapy.* 1997;35(3):231-238.
45. Woznowski-Vu A, Uddin Z, Flegg D, et al. Comparing Novel and Existing Measures of Sensitivity to Physical Activity Among People With Chronic Musculoskeletal Pain: The Importance of Tailoring Activity to Pain. *Clin J Pain.* 2019;35(8):656-667.
46. Damsgard E, Thrane G, Anke A, Fors T, Roe C. Activity-related pain in patients with chronic musculoskeletal disorders. *Disabil Rehabil.* 2010;32(17):1428-1437.

47. Palit S, Fillingim RB, Bartley EJ. Pain resilience moderates the influence of negative pain beliefs on movement-evoked pain in older adults. *Journal of behavioral medicine.* 2019.
48. Hadlandsmyth K, Sabic E, Zimmerman MB, et al. Relationships among pain intensity, pain-related distress, and psychological distress in pre-surgical total knee arthroplasty patients: a secondary analysis. *Psychol Health Med.* 2017;22(5):552-563.
49. Adams H, Thibault P, Davidson N, Simmonds M, Velly A, Sullivan MJ. Depression augments activity-related pain in women but not in men with chronic musculoskeletal conditions. *Pain Res Manag.* 2008;13(3):236-242.
50. Bartley EJ, Palit S, Fillingim RB, Robinson ME. Multisystem Resiliency as a Predictor of Physical and Psychological Functioning in Older Adults With Chronic Low Back Pain. *Front Psychol.* 2019;10:1932.
51. Cruz-Almeida Y, Cardoso J, Riley JL, et al. Physical performance and movement-evoked pain profiles in community-dwelling individuals at risk for knee osteoarthritis. *Experimental Gerontology.* 2017;98:186-191.
52. O'Sullivan P, Waller R, Wright A, et al. Sensory characteristics of chronic non-specific low back pain: a subgroup investigation. *Man Ther.* 2014;19(4):311-318.
53. Penn TM, Overstreet DS, Aroke EN, et al. Perceived Injustice Helps Explain the Association Between Chronic Pain Stigma and Movement-Evoked Pain in Adults with Nonspecific Chronic Low Back Pain. *Pain Med.* 2020.
54. Booker S, Cardoso J, Cruz-Almeida Y, et al. Movement-evoked pain, physical function, and perceived stress: An observational study of ethnic/racial differences in aging non-Hispanic Blacks and non-Hispanic Whites with knee osteoarthritis. *Exp Gerontol.* 2019;124:110622.
55. Crombez G, Vlaeyen JW, Heuts PH, Lysens R. Pain-related fear is more disabling than pain itself: evidence on the role of pain-related fear in chronic back pain disability. *Pain.* 1999;80(1-2):329-339.
56. Bartley EJ, Hossain NI, Gravlee CC, et al. Race/Ethnicity Moderates the Association Between Psychosocial Resilience and Movement-Evoked Pain in Knee Osteoarthritis. *ACR Open Rheumatol.* 2019;1(1):16-25.
57. Wideman TH, Edwards RR, Finan PH, Haythornthwaite JA, Smith MT. Comparing the Predictive Value of Task Performance and Task-Specific Sensitivity During Physical Function Testing Among People With Knee Osteoarthritis. *Journal of Orthopaedic & Sports Physical Therapy.* 2016;46(5):346-356.
58. Adegoke BOA, Boyinde OH, Odole AC, Akosile CO, Bello AI. Do self-efficacy, body mass index, duration of onset and pain intensity determine performance on selected physical tasks in individuals with unilateral knee osteoarthritis? *Musculoskelet Sci Pract.* 2017;32:1-6.
59. Rabey M, Smith A, Beales D, Slater H, O'Sullivan P. Differing Psychologically Derived Clusters in People With Chronic Low Back Pain are Associated With Different Multidimensional Profiles. *Clin J Pain.* 2016;32(12):1015-1027.
60. La Touche R, Grande-Alonso M, Arnes-Prieto P, Paris-Alemany A. How Does Self-Efficacy Influence Pain Perception, Postural Stability and Range of Motion in Individuals with Chronic Low Back Pain? *Pain Physician.* 2019;22(1):E1-E13.
61. Chimenti RL, Frey-Law LA, Sluka KA. A Mechanism-Based Approach to Physical Therapist Management of Pain. *Phys Ther.* 2018;98(5):302-314.
62. Sluka KA. *Mechanisms and management of pain for the physical therapist.* Lippincott Williams & Wilkins; 2016.
63. Archer KR, Motzny N, Abraham CM, et al. Cognitive-behavioral-based physical therapy to improve surgical spine outcomes: a case series. *Phys Ther.* 2013;93(8):1130-1139.
64. Malfliet A, Kregel J, Coppieters I, et al. Effect of Pain Neuroscience Education Combined With Cognition-Targeted Motor Control Training on Chronic Spinal Pain: A Randomized Clinical Trial. *JAMA Neurol.* 2018;75(7):808-817.
65. Van Oosterwijck J, Meeus M, Paul L, et al. Pain physiology education improves health status and endogenous pain inhibition in fibromyalgia: a double-blind randomized controlled trial. *Clin J Pain.* 2013;29(10):873-882.
66. Miller L, Ohlman T, Naugle KM. Sensitivity to Physical Activity Predicts Daily Activity Among Pain-Free Older Adults. *Pain Med.* 2018;19(8):1683-1692.
67. Luque-Suarez A, Martinez-Calderon J, Navarro-Ledesma S, Morales-Asencio JM, Meeus M, Struyf F. Kinesiophobia Is Associated With Pain Intensity and Disability in Chronic Shoulder Pain: A Cross-Sectional Study. *J Manipulative Physiol Ther.* 2020.

68. Huysmans E, Ickmans K, Van Dyck D, et al. Association Between Symptoms of Central Sensitization and Cognitive Behavioral Factors in People With Chronic Nonspecific Low Back Pain: A Cross-sectional Study. *Journal of manipulative and physiological therapeutics.* 2018;41(2):92-101.
69. Nijs J, Loggia ML, Polli A, et al. Sleep disturbances and severe stress as glial activators: key targets for treating central sensitization in chronic pain patients? *Expert Opin Ther Targets.* 2017;21(8):817-826.
70. Spector PE. Do Not Cross Me: Optimizing the Use of Cross-Sectional Designs. *J Bus Psychol.* 2019;34:125-137.

Figure 1. CONSORT diagram: selection process

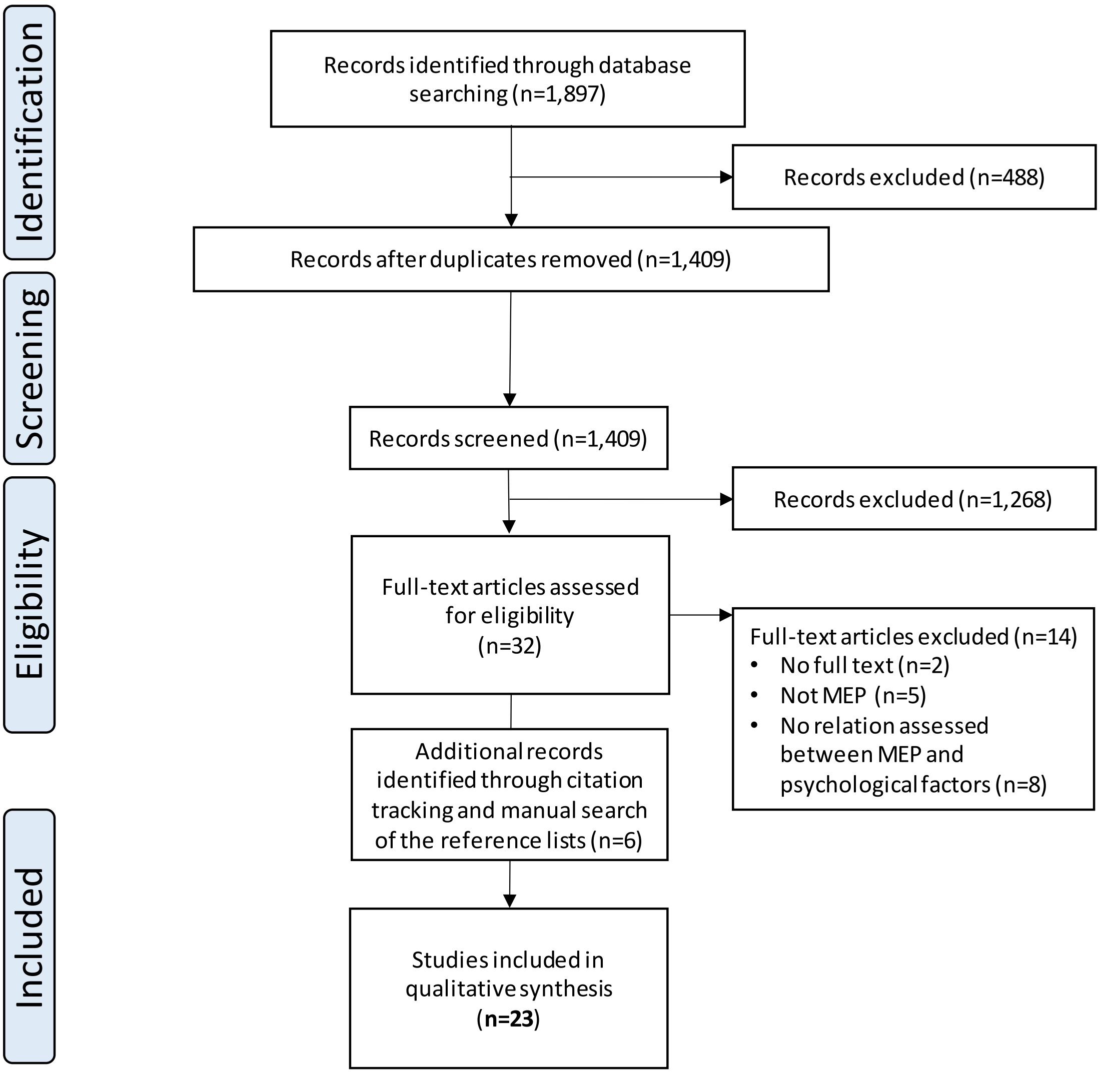


Figure 2. Risk of bias

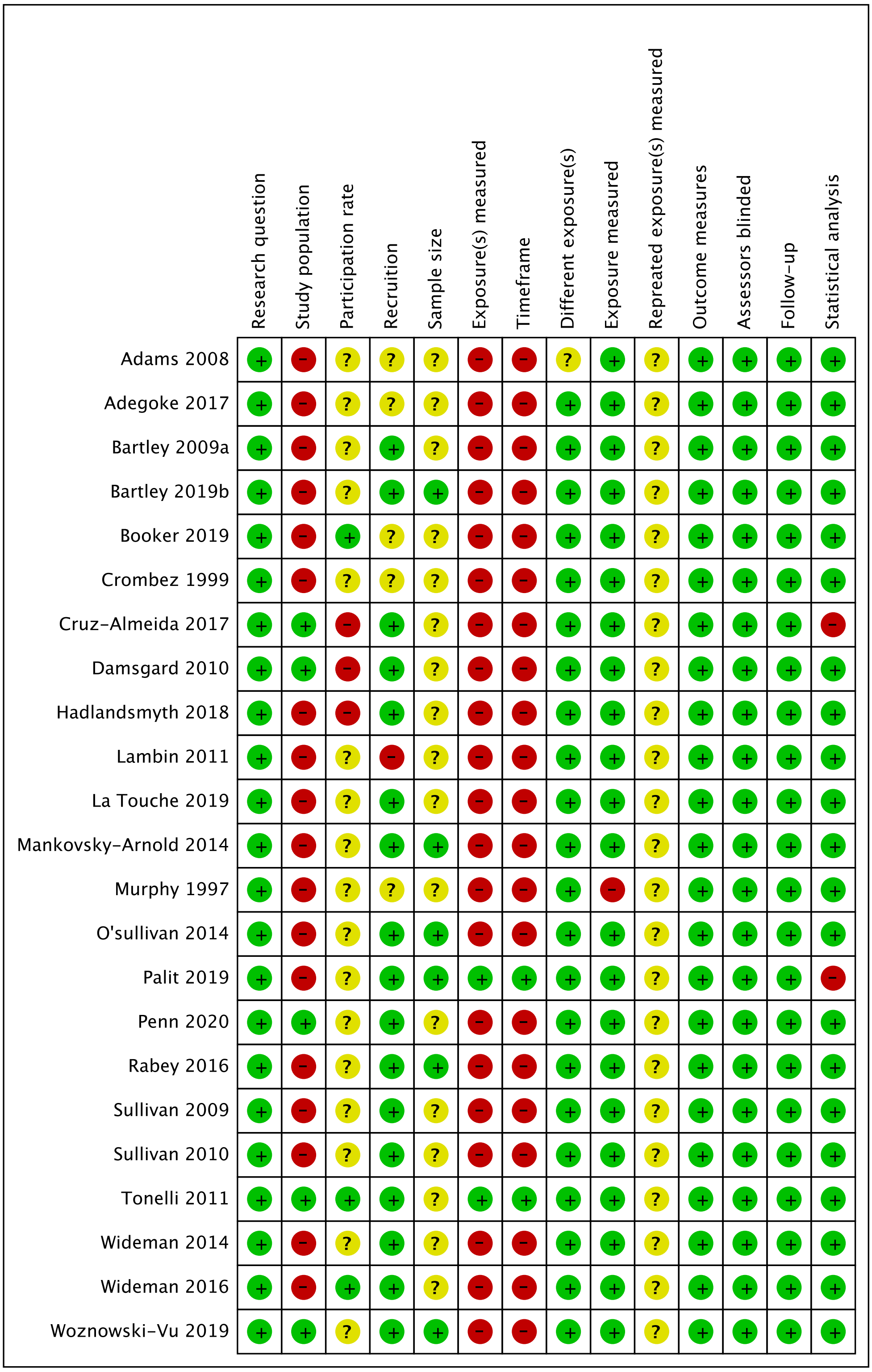
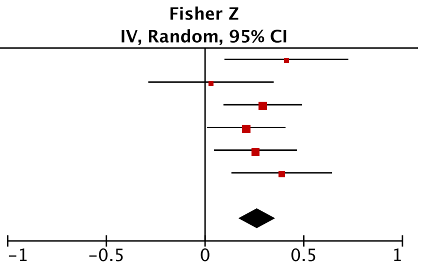


Figure 3. Forest plot on the association between movement-evoked pain and psychological factors in patients with musculoskeletal pain

A. Movement-evoked pain and depressive symptoms

Study or Subgroup	Fisher Z	SE	Weight	Fisher Z IV, Random, 95% CI
Adams 2008 (1)	0.4118	0.1601	9.4%	0.41 [0.10, 0.73]
Adams 2008 (2)	0.03	0.1622	9.1%	0.03 [−0.29, 0.35]
Lambin 2011	0.292	0.1015	23.3%	0.29 [0.09, 0.49]
Penn 2020	0.2089	0.1015	23.3%	0.21 [0.01, 0.41]
Sullivan 2009	0.2554	0.1072	20.9%	0.26 [0.05, 0.47]
Sullivan 2010	0.3884	0.1301	14.2%	0.39 [0.13, 0.64]
Total (95% CI)			**100.0%**	**0.27 [0.17, 0.36]**

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 4.22$, df = 5 (P = 0.52); $I^2 = 0\%$
Test for overall effect: Z = 5.43 (P < 0.00001)

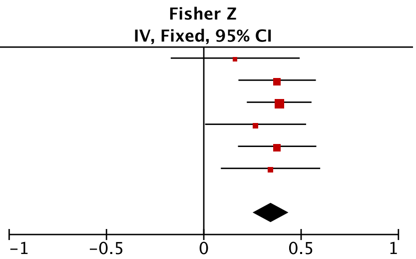


Footnotes
(1) women
(2) men

B. Movement-evoked pain and pain-related fear

Study or Subgroup	Fisher Z	SE	Weight	Fisher Z IV, Fixed, 95% CI
Crombez 1999	0.1614	0.169	7.3%	0.16 [−0.17, 0.49]
Lambin 2011	0.3769	0.1015	20.1%	0.38 [0.18, 0.58]
Mankovsky-Arnold 2014	0.3873	0.0848	28.9%	0.39 [0.22, 0.55]
Palit 2019	0.2661	0.1324	11.8%	0.27 [0.01, 0.53]
Sullivan 2009	0.3769	0.1027	19.7%	0.38 [0.18, 0.58]
Sullivan 2010	0.3428	0.1302	12.2%	0.34 [0.09, 0.60]
Total (95% CI)			**100.0%**	**0.35 [0.26, 0.44]**

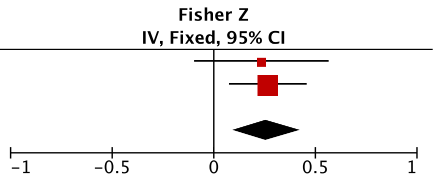
Heterogeneity: $Chi^2 = 1.98$, df = 5 (P = 0.85); $I^2 = 0\%$
Test for overall effect: Z = 7.62 (P < 0.00001)



C. Movement-evoked pain and negative affect

Study or Subgroup	Fisher Z	SE	Weight	Fisher Z IV, Fixed, 95% CI
Crombez 1999	0.2342	0.169	25.0%	0.23 [−0.10, 0.57]
Wideman 2016	0.2661	0.0976	75.0%	0.27 [0.07, 0.46]
Total (95% CI)			**100.0%**	**0.26 [0.09, 0.42]**

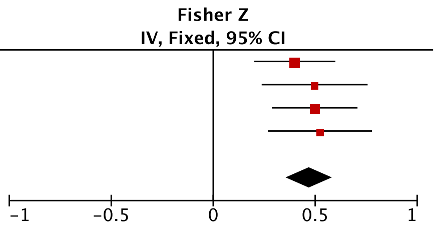
Heterogeneity: $Chi^2 = 0.03$, df = 1 (P = 0.87); $I^2 = 0\%$
Test for overall effect: Z = 3.05 (P = 0.002)



D. Movement-evoked pain and pain catastrophizing

Study or Subgroup	Fisher Z	SE	Weight	Fisher Z IV, Fixed, 95% CI
Lambin 2011	0.4001	0.1015	32.4%	0.40 [0.20, 0.60]
Palit 2019	0.4973	0.1325	19.0%	0.50 [0.24, 0.76]
Sullivan 2009	0.4973	0.1072	29.0%	0.50 [0.29, 0.71]
Sullivan 2010	0.523	0.1302	19.7%	0.52 [0.27, 0.78]
Total (95% CI)			**100.0%**	**0.47 [0.36, 0.58]**

Heterogeneity: $Chi^2 = 0.75$, df = 3 (P = 0.86); $I^2 = 0\%$
Test for overall effect: Z = 8.16 (P < 0.00001)

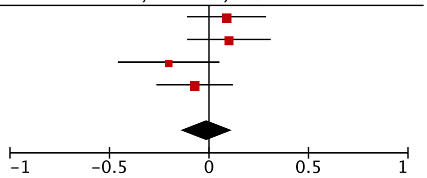


E. Movement-evoked pain index and depressive symptoms

Study or Subgroup	Fisher Z	SE	Weight	Fisher Z IV, Random, 95% CI
Lambin 2011	0.0882	0.1015	27.1%	0.09 [−0.11, 0.29]
Sullivan 2009	0.1003	0.1072	25.3%	0.10 [−0.11, 0.31]
Sullivan 2010	−0.2027	0.1302	19.3%	−0.20 [−0.46, 0.05]
Wideman 2014	−0.0721	0.0981	28.3%	−0.07 [−0.26, 0.12]
Total (95% CI)			**100.0%**	**−0.01 [−0.14, 0.12]**

Heterogeneity: $Tau^2 = 0.01$; $Chi^2 = 4.58$, df = 3 (P = 0.21); $I^2 = 35\%$
Test for overall effect: Z = 0.15 (P = 0.88)

Fisher Z IV, Random, 95% CI

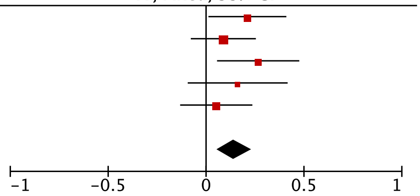


F. Movement-evoked pain index and pain-related fear

Study or Subgroup	Fisher Z	SE	Weight	Fisher Z IV, Fixed, 95% CI
Lambin 2011	0.2111	0.1015	19.6%	0.21 [0.01, 0.41]
Mankovsky-Arnold 2014	0.0882	0.0848	28.1%	0.09 [−0.08, 0.25]
Sullivan 2009	0.2661	0.1072	17.6%	0.27 [0.06, 0.48]
Sullivan 2010	0.1614	0.1302	11.9%	0.16 [−0.09, 0.42]
Woznowski-Vu 2019	0.052	0.0941	22.8%	0.05 [−0.13, 0.24]
Total (95% CI)			**100.0%**	**0.14 [0.06, 0.23]**

Heterogeneity: $Chi^2 = 3.14$, df = 4 (P = 0.53); $I^2 = 0\%$
Test for overall effect: Z = 3.20 (P = 0.001)

Fisher Z IV, Fixed, 95% CI



G. Movement-evoked pain index and pain catastrophizing

Study or Subgroup	Fisher Z	SE	Weight	Fisher Z IV, Fixed, 95% CI
Lambin 2011	0.1521	0.1015	21.0%	0.15 [−0.05, 0.35]
Sullivan 2009	0.1923	0.1072	18.8%	0.19 [−0.02, 0.40]
Sullivan 2010	0.2877	0.1302	12.7%	0.29 [0.03, 0.54]
Wideman 2014	0.2184	0.0968	23.1%	0.22 [0.03, 0.41]
Woznowski-Vu 2019	0.0601	0.0941	24.4%	0.06 [−0.12, 0.24]
Total (95% CI)			**100.0%**	**0.17 [0.08, 0.26]**

Heterogeneity: $Chi^2 = 2.51$, df = 4 (P = 0.64); $I^2 = 0\%$
Test for overall effect: Z = 3.65 (P = 0.0003)

Fisher Z IV, Fixed, 95% CI

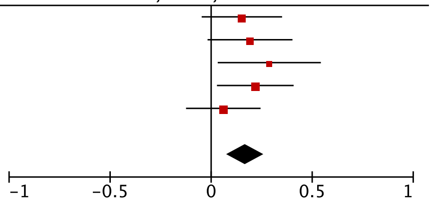


Table 1. Overview of studies, categorized by psychological factors in patients with musculoskeletal pain

Author and year	Study design	Participants (N; Pain condition; women (%))	MEP (Movement task; Calculation; Assessment tool)	Psychological factor (Construct (Assessment tool))	Results (p-value)
Anxiety					
[1] Hadlandsmyth 2017[48]	CS	N=346; knee OA; 54%	Active flexion/extension of the affected knee; Average score between flexion and extension pain ratings was used; NRS (0-20)	Sate anxiety (STAI)	r = N.R.
[1] Murphy 1997[44]	CS	N=20; CLBP; 70%	Walking test, stand-up test, stair climbing; Experienced pain during each exercise; Verbal VAS (0-10)	State anxiety (STAI)	**β** (walking)= N.R. (p > 0.05) **β** (stand-up test) **= -0.764, T = -2.877 (p = 0.010)** **β** (stair climbing) = N.R. (p > 0.05)
[1] Tonelli 2011[13]	C	N=208, Knee OA, 66.3%	Flexion, extension and walking; N.R.; NRS (0-20)	State anxiety (STAI)	β (walking) = 0.075 (p = 0.081) β (flexion and extension): N.R.
Chronic pain acceptance					
[2] Rabey 2016[59]	CS	N= 294; CLBP; 57.1%	Repeated spinal bending (20 forward and 20 backward spinal bends); MEP index (pain intensity score after last 5 repetitions subtracted from baseline pain score (first 5 repetitions)); NRS (0-10)	Chronic pain acceptance (CPAQ 8)	MEP index: Cluster 1 had a significantly greater proportion of people with no increase in pain following repeated movements and a lesser proportion of people with increased pain following repeated movement [c]
Depressive symptoms					
[1] Adams 2008[49] ‡	CS	N = 83; musculoskeletal pain; 51%	Canister lifting task; Average pain (18 canister lifts); VRS (0-10)	Depressive symptoms (BDI-II)	Women: **r = 0.39 (p < 0.01)** Men: r = 0.03 (p > 0.05)
[1] Bartley 2019a[50]	CS	N = 60; CLBP; 56%	Back Performance Scale; Average mean score of current LBP immediately after movement tasks; N.R. (0-100)	Depressive symptoms (PROMIS)	No differences (p = 0.08) were detected across cluster groups [a]
[1] Cruz-Almeida 2017[51]	CS	N=270; knee OA, 63%	Standing balance, 4-m walking, rise from a chair; Average pain; VAS (0-100)	Depressive symptoms (CES-D)	Cluster 3 reported significantly greater **depressive symptoms** than individuals in Cluster 1 [b]
[1] Hadlandsmyth 2017[48]	CS	N=346; knee OA; 54%	Active flexion/extension of the affected knee; Average score between flexion and extension pain ratings was used; NRS (0-20)	Depressive symptoms (GDS)	r = N.R.
[1,2] Lambin 2011[12] ‡ ∇	CS	N=100; fibromyalgia (n=50) and CLBP (n=50); 100%	Canister lifting task; Mean activity-related pain and MEP index (subtracting first pain ratings from peak pain ratings); VRS (0-10)	Depressive symptoms (BDI-II)	**r = 0.284 (p < 0.01)** MEP index: r = 0.088 (p > 0.05)

[1] O'Sullivan 2014[52]	CS	N=53; mechanical CLBP (N=17), non-mechanical, CLBP (N=19), and pain free controls (N=19); 64%	Mechanical pain; where pain is related to processes of peripheral sanitization and some degree of activity dependent central sensitization; VAS (0-10)	Depression, anxiety and stress (DASS 21)	Significant differences for DASS score between **($p < 0.001$)** - non-mechanical CLBP (median (IQR)): 30 (34) - mechanical CLBP (median (IQR)): 20 (18) - controls (median (IQR)): 10 (14)
[1] Penn 2020[53] ‡	CS	N=105; CLBP; 59%	Standing balance, 4-m walking, rise from a chair; pain experienced during the activity; NRS (0-100)	Depressive symptoms (CES-D)	r = **0.206 ($p < 0.05$)**
[2] Rabey 2016[59]	CS	N= 294; CLBP; 57.1%	Repeated spinal bending (20 forward and 20 backward spinal bends); MEP index (pain intensity score after last 5 repetitions subtracted from baseline pain score (first 5 repetitions)); NRS (0-10)	Depression, anxiety and stress (DASS 21)	MEP index: Cluster 1 had a significantly greater proportion of people with no increase in pain following repeated movements ($p < 0.001$) and a lesser proportion of people with increased pain following repeated movement ($p < 0.001$) [c]
[1,2] Sullivan 2009[11] ‡ ∇	CS	N=90; CLBP; 49%	Canister lifting task; Mean of activity-related pain and MEP index (subtracting first pain ratings from peak pain ratings); VRS (0-10)	Depressive symptoms (BDI-II)	**r = 0.25 ($p < 0.05$)** MEP index: r = 0.10 ($p > 0.05$)
[1,2] Sullivan 2010[10] ‡ ∇	CS	N=62; whiplash injuries; 48%	Canister lifting task; Mean activity-related pain and MEP index (subtracting first pain ratings from peak pain ratings); VRS (0-10)	Depressive symptoms (BDI-II)	**r = 0.37 ($p < 0.01$)** MEP index: r = -0.20 ($p > 0.05$)
[1] Tonelli 2011[13]	C	N=208, Knee OA, 66.3%	Flexion, extension and walking; N.R.; NRS (0-20)	Depressive symptoms (GDS-SF)	β (walking) = N.R. ($p > 0.05$) β (flexion and extension): N.R. ($p > 0.05$)
[2] Wideman 2014[14] ∇	CS	N= 107; Knee OA; 70.1%	6-minute walk test, average pain score MEP index (subtracting first pain ratings from peak pain ratings) over 2 trails; VRS (0-100)	Depressive symptoms (POMS)	MEP index: r = -0.072 ($p > 0.05$)
Distress					
[1] Booker 2019[54]	CS	N= 162; knee OA; 61%	Standing balance, walking, chair stand, maximal isometric strength test; Mean intensity pain; NRS (0-100)	Perceived distress (PSS)	F (standing balance) = 1.37 ($p = 0.24$) F (walking) = 3.59 ($p = 0.06$) F (chair stand) = 1.69 ($p = 0.20$) F (index knee strength test) = 0.02 ($p = 0.88$) F (non-index knee strength test) = 3.52 ($p = 0.06$)

[1] Damsgard 2010[46]	CS	N=232; various musculoskeletal complaints; 53%	Average pain experienced during latest week during activity; NRS (0-10)	Psychological distress (HSCL 25)	**β = 1.28 (p = 0.001)**
[1] Hadlandsmyth 2017[48]	CS	N=346; knee OA; 54%	Active flexion/extension of the affected knee; Average score between flexion and extension pain ratings was used; NRS (0-20)	Pain related distress (NRS)	**r = 0.86 (p < 0.01)**
Pain-related fear					
[1] Crombez 1999 (2)[55] ‡	CS	N=38; CLBP; 66%	Trunk-extension-flexion task; Maximum back pain experienced; Verbal graphical rating scale (0-100)	Fear Avoidance Beliefs (FABQ) Pain-related fear (TSK)	FABQ-physical: r = 0.18 (p > 0.05) FABQ-work: **r = 0.42 (p < 0.01)** r = 0.16 (p > 0.05)
[1] Damsgard 2010[46]	CS	N=232; various musculoskeletal complaints; 53%	Average pain experienced during latest week during activity; NRS (0-10)	Pain-related fear (TSK)	**β = 0.70 (p < 0.001)**
[1,2] Lambin 2011[12] ‡ ∇	CS	N=100; fibromyalgia (n=50) and CLBP (n=50); 100%	Canister lifting task; Mean activity-related pain and MEP index (subtracting first pain ratings from peak pain ratings); VRS (0-10)	Pain-related fear (TSK)	**r = 0.360 (p < 0.01)** MEP index: **r = 0.208 (p < 0.05)**
[2] La Touche 2019[60]	CS	N=60; nonspecific CLBP; 58%	Canister lifting task; MEP index (subtracting first pain ratings from peak pain ratings); VAS (0-10).	Fear avoidance beliefs (FABQ) Pain-related fear (TSK)	Patients were classified as having "high" or "low" self-efficacy based on CPSS-scores. MEP index: High self-efficacy group: r = 0.335 (p > 0.05) Low self-efficacy group: r = 0.206 (p > 0.05) MEP index: High self-efficacy group: **r = 0.711 (p < 0.01)** Low self-efficacy group: **r = 0.705 (p < 0.01)**
[1,2] Mankovsky-Arnold 2014[7] ‡ ∇	CS	N=142; whiplash; 48%	Canister lifting task; pain evoked by one lift and MEP index (pain intensity score after first 3 lifts subtracted pain intensity score after last 3 lifts); NRS (0-10)	Pain-related fear (TSK)	**r = 0.369 (p < 0.01)** MEP index: r = 0.088 (p > 0.05)
[1] Palit 2019[47] ‡	C	N=60; LBP; 56.7%	Back performance scale; average of pain ratings; N.R. (0-100)	Fear-avoidance beliefs (FABQ)	**r = 0.26 (p < 0.05)** **β = 0.46, t = 0.91 (p < 0.01)**
[2] Rabey 2016[59]	CS	N= 294; CLBP; 57.1%	Repeated spinal bending (20 forward and 20 backward spinal bends); MEP index (pain intensity score after last 5 repetitions subtracted	Fear avoidance beliefs (FABQ)	MEP index: Cluster 1 had a significantly greater proportion of people with no increase in pain following repeated movements (p < 0.001) and a lesser proportion of people with

			from baseline pain score (first 5 repetitions)); NRS (0-10)		bidirectional increases in pain following repeated movement (p < 0.001) [c]
[1,2] Sullivan 2009[11] ‡ ∇	CS	N=90; CLBP; 49%	Canister lifting task; Mean of activity-related pain and MEP index (subtracting first pain ratings from peak pain ratings); VRS (0-10)	Pain-related fear (TSK)	r = **0.36 (p < 0.01)** MEP index: **r = 0.26 (p < 0.05)**
[1,2] Sullivan 2010[10] ‡ ∇	CS	N=62; whiplash injuries; 48%	Canister lifting task; Mean activity-related pain and MEP index (subtracting first pain ratings from peak pain ratings); VRS (0-10)	Pain-related fear (TSK)	**r = 0.33 (p < 0.01)** MEP index: r = 0.16 (p > 0.05)
[2] Woznowski-Vu 2019[45] ∇	CS	N=116; Musculoskeletal pain; 69,8%	Self-paced walk, standardized lift, tailored lift; MEP index (subtracting first pain ratings from peak pain ratings); NRS (0-100)	Pain-related fear (TSK)	MEP index: r (walking) = 0.140 (p > 0.05) r (standardized lift) = 0.052 (p > 0.05) r (tailored task) = 0.110 (p > 0.05)
Pain catastrophizing					
[1] Cruz-Almeida 2017[51]	CS	N=270; knee OA, 63%	Standing balance, 4-m walking, rise from a chair; Average pain; VAS (0-100)	Coping strategies and pain catastrophizing (CSQ-R)	Cluster 3 reported significantly greater use of coping strategies, more catastrophizing individuals in Cluster 1 [b]
[1] Hadlandsmyth 2017[48]	CS	N=346; knee OA; 54%	Active flexion/extension of the affected knee; Average score between flexion and extension pain ratings was used; NRS (0-20)	Pain catastrophizing (PCS)	r = N.R.
[2] La Touche 2018[60]	CS	N=60; nonspecific CLBP; 58%	Canister lifting task; MEP index (subtracting first pain ratings from peak pain ratings); VAS (0-10). .	Pain catastrophizing (PCS)	Patients were classified as having "high" or "low" self-efficacy based on CPSS-scores. MEP index: High self-efficacy group: **r = 0.606 (p < 0.01)** Low self-efficacy group: **r = 0.765 (p < 0.01)**
[1,2] Lambin 2011[12] ‡ ∇	CS	N=100; fibromyalgia (n=50) and CLBP (n=50); 100%	Canister lifting task; Mean activity-related pain and MEP index (subtracting first pain ratings from peak pain ratings); VRS (0-10)	Pain catastrophizing (PCS)	**r = 0.380 (p < 0.01)** MEP index: r = 0.151 (p > 0.05)
[1] Palit 2019[47] ‡	C	N=60; LBP; 56.7%	Back performance scale; average of pain ratings; N.R. (0-100)	Pain catastrophizing (PCS)	**r = 0.46 (p < 0.01)** **β = 0.58, t = 2.13 (p < 0.001)**
[2] Rabey 2016[59]	CS	N= 294; CLBP; 57.1%	Repeated spinal bending (20 forward and 20 backward spinal bends); MEP index (pain intensity score after last 5 repetitions subtracted	Pain catastrophizing (PCS)	MEP index: Cluster 1 had a significantly greater proportion of people with no increase in pain following repeated movements

			from baseline pain score (first 5 repetitions)); NRS (0-10)		(p < 0.001) and a lesser proportion of people with increased pain following repeated movement (p < 0.001) [c]
[1,2] Sullivan 2009[11] ‡ ∇	CS	N=90; CLBP; 49%	Canister lifting task; Mean of activity-related pain and MEP index (subtracting first pain ratings from peak pain ratings); VRS (0-10)	Pain catastrophizing (PCS)	**r = 0.46 (p < 0.01)** MEP index: r = 0.19 (p > 0.05)
[1,2] Sullivan 2010[10] ‡ ∇	CS	N=62; whiplash injuries; 48%	Canister lifting task; Mean activity-related pain and MEP index (subtracting first pain ratings from peak pain ratings); VRS (0-10)	Pain catastrophizing (PCS)	**r = 0.48 (p < 0.01)** MEP index: r = 0.28 (p < 0.05)
[1] Tonelli 2011[13]	C	N=208, Knee OA, 66.3%	Flexion, extension and walking; N.R.; NRS (0-20)	Pain catastrophizing (PCS)	β (walking): N.R. (p > 0.05) β (flexion and extension): N.R. (p > 0.05)
[2] Wideman 2014[14] ∇	CS	N= 107; Knee OA; 70.1%	6-minute walk test, average pain score MEP index (subtracting first pain ratings from peak pain ratings) over 2 trails; VRS (0-100)	Pain catastrophizing (PCS)	MEP index: **r = 0.215 (p < 0.05)** **β = 0.222, T= 2.508 (p < 0.05)**
[2] Woznowski-Vu 2019[45] ∇	CS	N=116; Musculoskeletal pain; 69,8%	Self-paced walk, standardized lift, tailored lift; MEP index (subtracting first pain ratings from peak pain ratings); NRS (0-100)	Pain catastrophizing (PCS)	MEP index: r (walking) = 0.068 (p > 0.05) r (standardized lift) = 0.060 (p > 0.05) r (tailored lift) = -0.039 (p > 0.05)
Pain hypervigilance					
[1] Cruz-Almeida 2017[51]	CS	N=270; knee OA, 63%	Standing balance, 4-m walking, rise from a chair; Average pain; VAS (0-100)	Pain vigilance (PVAQ)	Cluster 3 reported significantly more pain hypervigilance than individuals in Cluster 1 [b]
Perceived injustice					
[1] Penn 2020[53]	CS	N=105; CLBP; 59%	Standing balance, 4-m walking, rise from a chair; pain experienced during the activity; NRS (0-100)	Perceived injustice (IEQ)	r = **0.496 (p < 0.001)**
Positive and negative affect					
[1] Bartley 2019a[50]	CS	N = 60; CLBP; 56%	Back Performance Scale; Average mean score of current LBP immediately after movement tasks; N.R. (0-100)	Positive and negative affect (PANAS)	No differences (p = 0.08) were detected across cluster groups [a]
[1] Bartley 2019b[56]	CS	N= 201; knee OA; 61%	Standing balance, 4-m walking, rise from a chair; Average mean score of LBP immediately after movement tasks; N.R. (0-100)	Positive and negative affect (PANAS)	r = -0.09 (p > 0.05)
[1] Crombez 1999 (2)[55] ‡	CS	N=38; CLBP; 66%	Trunk-extension-flexion task; Maximum back pain experienced; Verbal graphical rating scale (0-100)	Negative affect (NEM)	r = 0.23 (p > 0.05)

[1] Cruz-Almeida 2017[51]	CS	N=270; knee OA, 63%	Standing balance, 4-m walking, rise from a chair; Average pain; VAS (0-100)	Positive and negative affect (PANAS)	Cluster 3 reported significantly more negative affect than individuals in Cluster 1. All three clusters reported similar levels of positive affect ($p > 0.05$) [b]
[1] Wideman 2016[57] ‡	CS	N=108, Knee OA; 70.4%	6MWT, TUG test; post-task discomfort; VRS (0-100)	Positive and negative affect (VRS)	Positive affect: r (6MWT) **= 0.36 (p < 0.05)** Positive affect: r (TUG) **= -0.25 (p < 0.05)** Negative affect: r (6MWT) **= 0.56 (p < 0.05)** Negative affect: r (TUG) = **0.26 (p < 0.05)**
Positive well-being					
[1] Bartley 2019a[50]	CS	N = 60; CLBP; 56%	Back Performance Scale; Average mean score of current LBP immediately after movement tasks; N.R. (0-100)	Positive well-being (PROMIS positive affect and well-being)	No differences ($p = 0.08$) were detected across cluster groups [a]
[1] Bartley 2019b[56]	CS	N= 201; knee OA; 61%	Standing balance, 4-m walking, rise from a chair; Average mean score of LBP immediately after movement tasks; N.R. (0-100)	Positive well-being (PAW-SF)	r **= -0.16 (p < 0.05)**
Resilience					
[1] Bartley 2019a[50]	CS	N = 60; CLBP; 56%	Back Performance Scale; Average mean score of current LBP immediately after movement tasks; N.R. (0-100)	Trait resilience (BRS) Optimism (LOT-R)	No differences ($p = 0.08$) were detected across cluster groups [a]
[1] Bartley 2019b[56]	CS	N= 201; knee OA; 61%	Standing balance, 4-m walking, rise from a chair; Average mean score of LBP immediately after movement tasks; N.R. (0-100)	Trait resilience (BRS) Optimism (LOT-R)	**r = -0.17 (p < 0.05)** **r = -0.22 (p < 0.01)**
[1] Palit 2019[47]	C	N=60; LBP; 56.7%	Back performance scale; average of pain ratings; N.R. (0-100)	Pain resilience (PRS)	$r = -0.11$ ($p > 0.05$) $\beta = -0.03$, $t = -0.11$ ($p = 0.91$)
Self-efficacy					
[1] Adegoke 2017[58]	CS	N = 51; unilateral knee OA; 57%	Stair test (STT), 20m walking test (20MWT), Timed Up and Go Test (TUG)); Present pain; Box NRS (BNPS, 0-10)	Pain self-efficacy (PSE) and function (FSE) subscale	PSE: **r = -0.56 (p < 0.01)** FSE: **r = -0.52 (p < 0.01)**
[1] Damsgard 2010[46]	CS	N=232; various musculoskeletal complaints; 53%	Average pain experienced during latest week during activity; NRS (0-10)	Self-efficacy (ASES)	**β = -0.05 (p < 0.001)**
[2] Rabey 2016[59]	CS	N= 294; CLBP; 57.1%	Repeated spinal bending (20 forward and 20 backward spinal bends); MEP index (pain intensity score after last 5 repetitions subtracted from baseline pain score (first 5 repetitions)); NRS (0-10)	Pain self-efficacy (PSE)	MEP index Cluster 1 had a significantly greater proportion of people with no increase in pain following repeated movements ($p < 0.001$) and a lesser proportion of people with

				bidirectional increases in pain following repeated movement ($p < 0.001$) [c]

[1] studies investigating the relation between a certain psychological factor and MEP; [2] studies investigating the relation between a certain psychological factor and a MEP index.
‡: included in a meta-analysis MEP; ∇: included in meta-analysis MEP index

ASES, Arthritis Self-Efficacy Scale; BDI-II, Beck Depression Inventory-II; BRS, Brief Resilience Scale; C, cohort study; CES-D, Center for Epidemiological Studies – Depression; CLBP, chronic low back pain; CPAQ-8, Chronic Pain Acceptance Questionnaire 8; CPSS, Chronic Pain Self-Efficacy Scale; CS, cross-sectional study; CSQ-R, Coping Strategies Questionnaire-Revised; DASS-21, Depression Anxiety Stress Scale; FABQ, Fear Avoidance Beliefs Questionnaire; FSE, Function Self-Efficacy Scale; GDS, Geriatric Depression Scale; GDS-SF, Geriatric Depression Scale – Short Form; HSCL-25, Hopkins Symptoms Checklist – 25; IEQ, Injustice Experience Questionnaire; IQR, inter-quartile range; LBP, low back pain; LOT-R, Life Orientation Test-Revised; m, meter; MEP, movement-evoked pain; N, number; NEM, Negative Emotionality Scale; N.R., not reported; NRS, numeric rating scale; OA, osteoarthritis; PANAS, Positive And Negative Affect Schedule; PAW-SF, Positive Affect and Well-being – Short Form; PCS, Pain Catastrophizing Scale; POMS, Profile of Mood States; PROMIS, Patients-Reported Outcomes Measurement Information System; PRS, Pain Resilience Scale; PSE, Pain Self-Efficacy Scale; PSS, Perceived Stress Questionnaire; PVAQ, Pain Vigilance Awareness Questionnaire; STAI, State-Trait Anxiety Questionnaire; TSK, Tampa Scale for Kinesiophobia; VAS, visual analogue scale; VRS, Verbal rating scale.

[a] Four clusters were identified: (1) High Resilience group: high levels of psychological, health and social support functioning; (2) High Health/Low psychosocial group: optimal health related functioning, low levels of psychosocial function, (3) High psychosocial/Low health group: poor health functioning, high psychological functioning, moderate to high social support, (4) Low resilience group: low levels of functioning across psychological, social and health-related factors;

[b] Three clusters were identified: (1) High physical function and minimal MEP, (2) Moderate physical function and mild MEP, (3) Low physical function and severe MEP.

[c] Three clusters were identified: (1) Low cognitive and affective questionnaire scores, with exception of fear-avoidance beliefs, (2) elevated thought suppression, catastrophizing and fear-avoidance beliefs, but low pain self-efficacy, depression, anxiety and stress, (3) highest scores across cognitive and affective questionnaires.

Table 2. GRADE evidence profile: associations between psychological factors and movement-evoked pain (index) scores in patients with musculoskeletal pain.

Certainty Assessment							Nº of patients	Mean Correlation (95% C.I.)	Certainty	Comments
Nº of studies	**Study design**	**Risk of Bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other considerations**				
Movement-evoked pain and depressive symptoms										
5	observational studies	serious[1]	not serious	not serious	not serious	none	440	EMC 0.27 (0.17 to 0.36) p < 0.001*	⊕⊕⊕◯ MODERATE[2]	There is moderate evidence for a weak association between MEP and depressive symptoms.
Movement-evoked pain and pain-related fear										
6	observational studies	serious[1]	not serious	not serious	not serious	none	492	EMC 0.35 (0.26 to 0.44) p < 0.001*	⊕⊕⊕◯ MODERATE[2]	There is moderate evidence for a weak association between MEP and pain-related fear.
Movement-evoked pain and negative affect										
2	observational studies	serious[1]	not serious	not serious	serious[3]	none	146	EMC 0.26 (0.09 to 0.42) p = 0.002*	⊕⊕◯◯ LOW	There is limited evidence for a weak association between MEP and negative affect.
Movement-evoked pain and pain catastrophizing										
4	observational studies	serious[1]	not serious	not serious	not serious	none	312	EMC 0.47 (0.36 to 0.58) p < 0.001*	⊕⊕⊕◯ MODERATE[2]	There is moderate evidence for a moderate association between MEP and pain catastrophizing.

Movement-evoked pain index and depressive symptoms										
4	observational studies	serious[1]	not serious	not serious	not serious	none	359	EMC -0.01 (-0.14 to 0.12) p = 0.88	⊕⊕⊕◯ MODERATE[2]	There is moderate evidence for a weak association between MEP and depressive symptoms.
Movement-evoked pain index and pain-related fear										
5	observational studies	serious[1]	not serious	not serious	not serious	none	510	EMC 0.14 (0.06 to 0.23) p = 0.001*	⊕⊕⊕◯ MODERATE[2]	There is moderate evidence for a weak association between MEP and pain-related fear.
Movement-evoked pain index and pain catastrophizing										
5	observational studies	serious[1]	not serious	not serious	not serious	none	475	EMC 0.17 (0.08 to 0.26) p < 0.001*	⊕⊕⊕◯ MODERATE[2]	There is moderate evidence for a weak association between MEP and pain catastrophizing

CI, confidence interval; EMC, estimated mean correlation (Fisher z); MEP, movement-evoked pain; *, statistically significant.

[1]As the overall risk of bias of the included studies can be considered high risk of bias, level of evidence was downgraded for within study risk of bias: , [2] The presence of a dose-response gradient increases the confidence in these findings of observational studies, and therefore, the level of evidence was upgraded, [3] Since less than 400 participants were included, optimal information size (OIS) is not met and therefore the level of evidence was downgraded for imprecision.