The relationship between pain-related psychological factors and maximal physical performance in low back pain: a systematic review and meta-analysis.

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Short study description

The premise of maximal physical performance tests is that they are mainly limited by physical constraints. However, various theoretical frameworks explain how pain-related psychological factors may also influence physical functioning and performance. In this systematic review and meta-analysis, we evaluated the available evidence regarding the relationship between pain-related psychological factors and maximal physical performance (e.g., strength) in patients with low back pain. Meta-analyses were performed for the different psychological constructs that could be retrieved (e.g., pain-related fear). In addition, we conducted various pre-defined subanalyses to examine whether associations were dependent on the type of performance test (e.g., strength *vs* endurance) or self-report measure to assess the psychological construct (e.g., TSK *vs* FABQ). Sensitivity analyses were done to assess the influence of personal factors (e.g., sex or age) and pain intensity.

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Abstract

Theoretical frameworks explain how pain-related psychological factors may influence physical performance. In this systematic review and meta-analysis, we evaluated the evidence regarding the relationship between pain-related psychological factors and maximal physical performance in patients with low back pain (LBP). Pubmed, Embase, CINAHL and Web of Science databases were searched from inception to May 2022. Cross-sectional or longitudinal studies reporting cross-sectional measures of association between at least one pain-related psychological factor and a quantitatively measured outcome of maximal physical performance in patients with LBP were eligible for inclusion. Thirty-eight studies (n=2490; 27 cross-sectional studies, n=1647 (66%); 11 longitudinal studies, n=843 (34%)) were included, with 92% of participants (n=2284) having chronic LBP. Results showed that pain-related fear, pain catastrophising and anticipated pain were consistently and negatively associated with maximal physical performance in chronic LBP, whereas pain-self efficacy showed positive correlations. Overall, magnitudes of absolute pooled r-values were small (r≤0.25), except for anticipated pain, which was moderately associated with maximal physical performance (r=-0.34 to -0.37). Subanalyses and sensitivity analyses yielded similar pooled correlation coefficients. Certainty of evidence using the GRADE recommendations was very low to moderate for pain-related fear, and very low to low for the other pain-related psychological factors.

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Perspective: *Overall, small pooled correlation coefficients were shown between pain-related psychological factors and maximal physical performance in chronic LBP. Certainty of evidence was very low to low for all pain-related psychological factors other than pain-related fear. Future studies taking into account limitations of the current literature may therefore change these conclusions.*

Key words: low back pain; physical performance; behaviour; psychological factors; systematic review

1. INTRODUCTION

Low back pain (LBP) poses an enormous health and socioeconomic problem. It has been identified as the leading cause of years lived with disability worldwide, and is one of the most important reasons for sick leave and early retirement.[17, 49]

Low back pain is a multidimensional problem that can be influenced by a myriad of factors, including physical, psychological and social aspects.[24] Consequently, this multidimensional nature should be taken into account during assessment in order to evaluate the relative contribution of these aspects for each individual patient. Regarding the physical component, maximal physical performance tests are often used to evaluate muscle strength, muscle endurance and functional capacity in patients with LBP.[36, 73] Although it can be questioned whether improvements in maximal physical performance are necessary to obtain reductions in pain and disability,[74] rehabilitation programmes can be individualised and progress can be monitored based on these type of tests, while functional capacity evaluations may also be useful for the prognosis of work participation.[41, 59]

The premise of maximal physical performance tests is that they are mainly limited by physical constraints. However, various theoretical frameworks explain how psychological factors may also influence physical functioning and performance, in particular in pain populations.[8, 26, 46, 90] The fear-avoidance model of pain posits that maladaptive pain-related cognitions (e.g., catastrophic thinking) may lead to pain-related fear of movement, and subsequently to avoidance behaviour and deconditioning.[14, 90] In addition, individuals with chronic pain and higher levels of pain-related fear typically overpredict the pain intensity they will experience during physical tasks, which in turn may interfere with the performance on these tasks.[14] However, fear and (predicted) pain are not the sole motivators of avoidance behaviour, and some pain-related psychological factors may actually reduce the latter.[52] For example, individuals who are more confident in their ability to perform activities despite their pain (i.e., higher pain self-efficacy) or individuals who are more strongly motivated to pursue valued life goals (i.e., goal pursuit) are more likely to engage and persist in (feared) activities.[8, 83, 84] Accordingly, it can be argued that pain-related psychological factors could also influence the achievements on maximal physical performance tests. In this case, results on such tests may rather reflect (pain-related) behaviour instead of true physiological capacity in patients with maladaptive pain-related cognitions, and thus significantly impact the interpretation of performance test outcomes. On the other hand, if pain-related psychological factors and maximal physical performance are not related, the theoretical underpinning of current models suggesting this relationship may need to be revised.

Despite a long history of empirical research in patients with LBP, the potential interplay between pain-related psychological factors and physical performance remains unclear, as shown by two previous literature reviews.[32, 82] However, these reviews did not include meta-analyses,[32, 82] and one review was not based on a systematic literature search.[32] Moreover, a significant number of additional studies have been published since. Given the important consequences for the empirical validation of theoretical frameworks and the interpretation of physical performance test results, a systematic review with meta-analysis on this topic is necessary. Therefore, a meta-analytic review was performed to determine whether pain-related psychological factors are associated with maximal physical performance in patients with LBP.

2. METHODS

2.1 Protocol and registration

This review was performed and reported according to the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) and PERSiST (implementing Prisma in Exercise, Rehabilitation, Sport medicine and SporTs science) guidelines.[7, 57] The review protocol was prospectively registered on PROSPERO (CRD42021227486).

2.2 Eligibility criteria

Participants: Studies including adults (≥18y) with LBP of musculoskeletal origin (including specific LBP; e.g., radicular pain) irrespective of the duration of complaints. Studies were excluded when they only included healthy persons or a heterogeneous pain-population without a specific analysis for LBP, when they were performed in a population with a serious underlying non-musculoskeletal disease (e.g., multiple sclerosis) or when experimentally induced pain was used.

Type of studies: Cross-sectional studies or cross-sectional baseline data from studies with a longitudinal design, including randomised controlled trials.

Outcome measures: At least one measure of association between a pain-related psychological factor and the outcome on a maximal voluntary physical performance test had to be reported. If only significant measures of association were reported and non-significant associations were only described as such, we contacted the authors of these studies at least three times. When we were not able to obtain the results for all associations (i.e., also the non-significant ones), this study was excluded in order to avoid positively biased results. To be included, the questionnaires assessing the psychological factors had to pertain to pain-related cognitions or emotions. For example, studies assessing pain anxiety or pain self-efficacy (e.g., using the Pain Anxiety Symptoms Scale of Pain Self-Efficacy Questionnaire) were included, whereas studies assessing anxiety or self-efficacy as a general construct not specifically pertaining to pain (e.g., using the Hospital Anxiety and Depression Scale or the General Self-Efficacy Scale) were not included. The physical performance test was considered maximal when the test was explicitly described as such, the authors referred to a previous study describing the test as maximal, or when it could be logically inferred from the definition of the test. The performance also had to be assessed quantitatively. Typical examples are endurance tests (e.g., maximal holding time in seconds), strength tests (e.g., maximal torque) or maximal functional capacity tests (e.g., maximal weight lifted for lifting capacity). Studies were excluded when only submaximal performance tests were included, if participants' cognitions were experimentally manipulated, and when the performance was rated via participant self-report or an assessor evaluation (e.g., using a Likert scale ranging from 'can do the task with ease' to 'cannot perform the task at all',[76] or via a rating of perceived exertion).

2.3 Information sources and search strategy

The electronic databases Pubmed, Embase, CINAHL and Web of Science were searched from inception to May 2022. Search terms for LBP, pain-related psychological factors and performance tests were combined (see supplementary appendix A for full strategy). The reference lists of included studies and other relevant papers were manually checked and forward citation tracking in Web of Science was used to find additional relevant papers.

2.4 Study selection

After removal of duplicates via a reference management tool (Endnote, version X9.2), two reviewers (T.M. and L.D.B.) independently screened the titles and abstracts of the obtained articles for eligibility. The relevant studies were read in full length to make a decision about the inclusion. In case of disagreement, a decision was made by consensus, and a third reviewer (L.J.) was consulted when necessary.

2.5 Risk of bias

The Quality In Prognosis Studies (QUIPS) tool was used to assess risk of bias.[28] Six domains were assessed and rated as low, moderate or high risk of bias: study participation, study attrition, prognostic factor measurement, outcome measurement, study confounding and statistical analysis and reporting. Since physical performance can be influenced by personal factors, such as age, sex and bodyweight,[64] the risk of bias assessment for study confounding was dependent on how many of these potentially confounding factors were taken into account, i.e., high (no factors), moderate (one factor) and low (at least two factors) risk of bias. For a study to be considered low risk of bias, at least 4/6 domains had to be low risk, including the domains 'study confounding' and 'statistical analysis and reporting'. Risk of bias was assessed independently by two authors (T.M. and L.D.B.). In case of disagreement, a third author (L.J.) was consulted to reach consensus. A Kappa-coefficient was calculated for evaluating interrater agreement for risk of bias assessment. Details on procedures for risk of bias assessment can be found in supplementary appendix B.

2.6 Data collection

Two authors (T.M. and L.D.B.) independently extracted the data using a standardised form, and verified the consistency of the extracted data afterwards. The following information was extracted regarding (1) study population: number of included participants, age, sex (% female), pain intensity, LBP-related disability, time since onset of LBP and type of LBP: acute (<6 weeks), subacute (6-12 weeks), chronic (≥12 weeks) or recurrent LBP; (2) pain-related psychological factors: the psychological construct (e.g., pain-related fear), the questionnaires used and the scores on the questionnaires and their relevant subscales; (3) maximal physical performance test: the type of task (e.g., strength), the involved body region (e.g., lower back or extremities), type of outcome (e.g., maximal weight lifted), whether and which type of familiarisation was performed in preparation of the task, and the type of motivational cues used during the performance task; (4) measures of association between pain-related psychological factors and results on maximal physical performance tests. Our approach was similar to a recent meta-analysis by Christe *et al*.[11] When only regression analyses were reported, the correlation coefficients were derived from the standardised beta coefficient as described by Peterson and Brown.[62] In case only between-group differences were available, correlation coefficients were calculated according to Jacobs *et al*[35]; (5) confounding factors:

we extracted whether the study design or statistical analysis took into account or adjusted for relevant personal confounders (age, sex, bodyweight) and pain intensity.

2.7 Data synthesis and meta-analysis

Data were analysed separately for (sub)acute LBP, chronic LBP and recurrent LBP in remission. The reason for this distinction is that the temporary avoidance of certain activities might be beneficial in case of (sub)acute injury, while this behaviour becomes maladaptive once the tissues have healed and protection is no longer necessary, as is assumed to be the case in chronic non-specific LBP and recurrent LBP in remission.[30]

A meta-analysis was performed when at least three studies were available for a particular analysis. Given the low number of studies including patients with (sub)acute LBP (n=1)[31] and recurrent LBP in remission (n=2),[5, 6] results for these types of LBP were reported descriptively. For the meta-analyses in the chronic LBP population, we first used a general approach where all the results for the same psychological construct were combined. Four different psychological constructs were retrieved from the studies, i.e., pain-related fear, pain catastrophising, anticipated pain during the performance test and pain self-efficacy. We hypothesised that (1) higher levels of pain-related fear, pain catastrophising and anticipated pain would be associated with worse physical performance, resulting in *negative* pooled correlation coefficients, whereas (2) higher levels pain self-efficacy would be associated with better physical performance, resulting in *positive* pooled correlation coefficients.

Next, per psychological construct we performed various subanalyses that were based on:

(1) The type of maximal performance test: based on the included studies, four categories could be made, i.e., muscle strength, muscle endurance, lifting capacity and functional mobility. The functional mobility category included tasks that were similar to daily life mobility activities (e.g., stair climbing or stationary cycling). Since lifting is often perceived to be a

harmful activity by patients with LBP,[50] we hypothesised that associations with pain-related psychological factors may be stronger for this task as compared to other tasks. Muscle strength tests were further divided in tests for respectively trunk and extremity muscles, as it could be hypothesised that performances on tasks involving the painful area (i.e., the trunk) may be affected to a higher degree by pain-related psychological factors compared to task involving remote areas (i.e., the extremities).

(2) The specific questionnaire: separate meta-analyses were performed for the different questionnaires that measure the same psychological construct. Furthermore, when a questionnaire consisted of different subscales, an additional analysis was made for each subscale that assesses a pain-related psychological factor. It has been hypothesised that some questionnaires or subscales may be more strongly related to physical performance, because their items specifically refer to physical activity and exercises (e.g., Tampa Scale for Kinesiophobia-Activity Avoidance subscale) whereas others do not (e.g., Tampa Scale for Kinesiophobia-Somatic Focus subscale).[69]

(3) The combination of the type of maximal performance test and the specific questionnaire: per questionnaire, subanalyses were performed for specific types of maximal performance tests.

In order to perform the meta-analyses, an average correlation coefficient per study was calculated if necessary.[11] For example, if a study reported correlation coefficients between lifting capacity and both the Fear Avoidance Beliefs Questionnaire and Tampa Scale for Kinesiophobia, these correlation coefficients were averaged to obtain a single correlation coefficient to assess the association between the construct pain-related fear and lifting capacity. When a single correlation coefficient was available for each analysis, they were first transformed using a Fisher's z transformation. Meta-analyses were performed using the z-scores, after which an inverse Fisher's z transformation was used to obtain the pooled correlation coefficient and 95% confidence interval (95% CI).[63] Pooled correlation coefficient effect sizes were interpreted as small ($r < 0.30$), moderate ($r = 0.30$-0.50) or strong ($r > 0.50$).[12] A random effects model was used for all meta-analyses. The I^2 statistic was used to describe the percentage of variability in effect estimates due to heterogeneity,[29] and potential outliers or influential cases were assessed according to Viechtbauer *et al*.[87] If present, sensitivity analyses were performed excluding these studies. Publication bias was assessed with funnel plots and Egger's regression when more than 10 studies were included in the meta-analysis.[75] Statistical analyses were performed using R software using the 'metafor' package.

Since the performance on maximal physical performance tests may be significantly influenced by personal factors, such as age, sex and bodyweight,[64] we performed sensitivity analyses with only studies that had low risk of bias on the categories 'study confounding' (i.e., controlling for at least two of these parameters) and 'statistical analysis and reporting'. To investigate the potential influence of pain intensity, we also performed a sensitivity analysis including studies with low risk of bias on the two abovementioned categories, and which statistically controlled for pain intensity.

2.8 Certainty of evidence

Two reviewers (T.M. and L.D.B.) independently assessed the certainty of evidence for the meta-analyses of the general and subanalyses using a modified version of the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) criteria.[10, 18, 48] We did not downgrade the certainty of evidence for non-RCT designs, as this was not a review about effectiveness of interventions and because non-randomised cross-sectional designs were appropriate for our research question. As such, the initial certainty of evidence was high, and could be downgraded for following reasons: (1) study limitations when >25% (-1 level) or >50% (-2 levels) of participants came from studies with high risk of bias; (2) inconsistency when I^2 was >50% (-1 level); (3) imprecision when the meta-analysis contained <400 participants (-1 level) or <100 participants (-2 levels); (4) publication bias, if present on funnel plots and Egger's regression for meta-analyses including ≥10 studies. We did not downgrade certainty of evidence for indirectness, since our inclusion criteria resulted in satisfaction of this criterion.[27] The certainty of evidence was upgraded if the effect size was moderate or large, i.e., absolute value of pooled correlation coefficient >0.30 (+1 level).

2.9 Deviations from protocol

Although we registered all of our subanalyses in the review protocol, we did not mention the specific hypotheses they were based on. Furthermore, we did not mention the sensitivity analyses that were performed.

3. RESULTS

3.1 Study selection

The search strategy resulted in 7982 papers. After removing duplicates and screening on title and abstract, the full texts of 220 papers were read. Finally, 38 studies (36 reports, 2432 participants) were included in the review. Two reports[16, 68] each described two separate studies in different patient samples. A flowchart is shown in Fig. 1.

3.2 Study characteristics

The majority of studies (35/38, 92%) included patients with chronic LBP. One study was performed in patients with (sub)acute LBP.[31] Two studies[5, 6] reported results on the same cohort of patients with recurrent LBP in remission. Roelofs *et al*[69] partially reanalysed data from a previous study in patients with chronic LBP that is also included in this review.[91] Therefore, we only included the unique data reported in Roelofs *et al*.[69]

Pain-related fear was assessed in 33 studies,[2-6, 15, 16, 21-23, 31, 34, 39, 42-44, 54-56, 67-72, 79, 80, 85, 86, 88, 91] pain catastrophising in eight studies,[5, 6, 16, 23, 42, 54, 58, 86] anticipated pain in five studies,[2, 4, 16, 65, 66] and pain

self-efficacy in four studies.[37, 38, 42, 54] Regarding the maximal physical performance tests, trunk muscle strength was evaluated in 19 studies,[3, 4, 16, 21-23, 34, 37-39, 42-44, 54, 56, 58, 66, 80, 85] lifting capacity in 12 studies,[16, 43, 55, 65, 66, 68-72, 79, 91] functional mobility in eight studies,[2, 43, 55, 65, 69, 71, 85, 88] trunk muscle endurance in six studies[5, 6, 21, 56, 68, 70] and extremity muscle strength in five studies.[15, 31, 34, 55, 86]
A summary and detailed description of study characteristics are provided in Table 1 and supplementary appendix C, respectively. The specific questionnaires (and their scores) that were used to assess the pain-related psychological factors for each study can also be found in supplementary appendix C. Overall, levels of pain-related psychological factors across the studies that were included in the meta-analyses were similar to clinically relevant scores for patients with LBP (e.g., weighted mean TSK-17 score across studies= 38.1/68 (pooled SD 7.4); see supplementary appendix D).[19, 47, 89, 95]

3.3 Risk of bias and publication bias

Results of the risk of bias assessment can be found in Table 2. The Kappa coefficient for inter-rater agreement was 0.76. Risk of bias related to study participation was rated low in only 14 studies (39%)[2-4, 21-23, 39, 55, 56, 66, 67, 70, 71, 85] because the time frame or place of patient recruitment were often not reported. Study attrition was rated low risk of bias, except for two studies.[79, 91] Regarding study confounding, 18 studies (44%)[5, 15, 16, 21-23, 31, 37, 38, 55, 67, 68, 71, 85, 86, 88] considered at least two personal factors in the design or statistical analysis. As a result, 18 studies (44%)[5, 15, 16, 21-23, 31, 37, 38, 55, 67, 68, 71, 85, 86, 88] were rated as low risk of bias. No publication bias was present for the four meta-analyses containing ≥10 studies (see supplementary appendix E).

3.4 Associations between pain-related psychological factors and maximal physical performance

3.4.1 (Sub)acute low back pain

One study (n=111)[31] in patients with (sub)acute LBP reported that pain-related fear was not significantly associated with maximal isometric quadriceps torque when controlling for age, sex and bodyweight (r= -0.16, p> 0.05). However, a significant association was present (r= -0.48, p< 0.01) in a subgroup of patients (n= 30) who overpredicted their pain during the task, while this was not the case for patients who made a correct prediction (r= 0.11, p> 0.05).

3.4.2 Recurrent low back pain in remission

Two studies reported results on the same cohort of patients with recurrent LBP in remission (n=24) who performed two types of maximal endurance tests for the lumbar extensor muscles.[5, 6] In both studies, pain-related fear (-0.28 < r < -0.19), pain catastrophising (-0.09 < r < 0.06) and pain-resilience (-0.36 < r < -0.3) were not significantly associated with muscle endurance (all p-values > 0.05). When controlling for trunk mass, pain-related fear was significantly associated with trunk muscle endurance in one study,[5] but not in the other study,[6] while correlations with pain catastrophising and pain-resilience remained non-significant in both studies (all p-values > 0.05).

3.4.3 Chronic low back pain

The results of the meta-analyses and the GRADE certainty of evidence assessment are summarised in Table 3. Forest plots of the meta-analyses are provided in supplementary appendix F.

3.4.3.1 Pain-related fear

All questionnaires combined

When combining all pain-related fear questionnaires and all types of maximal physical performance tests, a total of 30 studies (n= 1877)[2-4, 15, 16, 21-23, 34, 39, 42-44, 54-56, 67-72, 79, 80, 85, 86, 88, 91] showed a significant pooled correlation coefficient of -0.11 (95% CI= -0.15, -0.06). Looking at the different types of maximal performance tests separately, the pooled correlation coefficients for trunk muscle strength (15 studies, n= 849),[3, 4, 16, 21-23, 34, 39, 42-44, 54, 56, 80, 85] trunk muscle endurance (5 studies, n= 332),[21, 56, 68, 70] lifting capacity (12 studies, n= 983)[16, 39, 43, 55, 67, 68, 70-72, 79, 91] and functional mobility (8 studies, n= 744)[2, 43, 55, 69-71, 85, 88] were statistically significant and ranged between -0.08 and -0.22 (all p-values <0.03). In contrast, the pooled correlation coefficient for extremity muscle strength (4 studies, n=263) was not significant (r= 0.02; 95% CI= -0.11, 0.14).[15, 34, 55, 86] Certainty of evidence was low to moderate.

Tampa Scale for Kinesiophobia (TSK)

Meta-analyses could be performed for the total score on the TSK and for the TSK-Activity Avoidance subscale.

Tampa Scale for Kinesiophobia–Total score: The pooled correlation coefficient for all studies using the TSK-total score (18 studies, n= 1161) was -0.11 (95% CI= -0.17, -0.05).[16, 21, 23, 34, 39, 42, 54, 56, 67, 68, 70-72, 85, 86, 88, 91] Subanalyses per type of task showed that trunk muscle strength (9 studies, n= 531),[16, 21, 23, 34, 39, 42, 54, 56, 85] trunk muscle endurance (4 studies, n= 274)[21, 56, 68, 70] and lifting capacity (7 studies, n= 580)[16, 39, 67, 68, 70-72] were significantly associated with TSK-total scores (pooled r-range= -0.19 to -0.11, all p-values <0.05). Functional mobility (3 studies, n= 377)[71, 85, 88] was not significantly associated with TSK-Total scores (pooled r= -0.04; 95%CI= -0.14, 0.07). Certainty of evidence was moderate, except for trunk muscle endurance (very low certainty of evidence).

Tampa Scale for Kinesiophobia–Activity Avoidance Subscale: The pooled correlation for three studies (n= 111) was not statistically significant (r= -0.23; 95% CI= -0.56, 0.17). Certainty of evidence was very low.

Fear-Avoidance Beliefs Questionnaire (FABQ)

Studies only reported associations for the FABQ-Physical Activity and the FABQ-Work subscale separately, so results are presented accordingly.

Fear-Avoidance Beliefs Questionnaire–Physical Activity subscale: The pooled correlation coefficient of eight studies (n= 391)[2-4, 16, 39, 44, 68, 72] was -0.11 (95% CI= -0.27, 0.06). Subanalyses per task resulted in non-significant pooled correlation coefficients for trunk muscle strength (5 studies, n=247; r= -0.13; 95%CI= -0.36, 0.13)[2, 3, 16, 39, 44] and lifting capacity (3 studies, n= 144; r= -0.04; 95%CI= -0.21, 0.13).[39, 68, 72] Certainty of evidence was very low.

Fear-Avoidance Beliefs Questionnaire–Work subscale: The pooled correlation coefficient from eight studies (n= 484)[3, 4, 16, 39, 44, 55, 68, 72] was -0.09 (95% CI= -0.18, -0.01). Subanalyses per type of task resulted in non-significant pooled correlation coefficients for trunk muscle strength (4 studies, n= 205; r= -0.13; 95% CI= -0.27, 0.01) and for lifting capacity (4 studies, n= 270; r= -0.11, 95% CI= -0.27, 0.04).[39, 55, 68, 72] Certainty of evidence was low to very low.

Pain Anxiety Symptoms Scale

The pooled correlation coefficient from three studies (n=129)[16, 79, 80] was not significant (r= -0.16; 95% CI= -0.49, 0.21). Certainty of evidence was very low.

3.4.3.2 Pain catastrophising

All questionnaires combined

Six studies (n=405)[16, 23, 42, 54, 58, 86] investigated the association between pain catastrophising and maximal physical performance. This resulted in a significant pooled correlation coefficient of -0.18 (95% CI= -0.27, -0.08). Four studies (n=349)[23, 42, 54, 58] evaluated trunk muscle strength, resulting in a significant pooled correlation coefficient of -0.15 (95%CI= -0.26, -0.05). Certainty of evidence was low.

Pain Catastrophising Scale

The pooled correlation coefficient of four studies (n=194)[16, 23, 42, 54] was -0.18 (95% CI= -0.32, -0.04). Three of these studies (n=163)[23, 42, 54] investigated the relation with trunk muscle strength, which resulted in a non-significant pooled correlation coefficient of -0.13 (95% CI= -0.29, 0.02). Certainty of evidence was low.

3.4.3.3 Pain Self-Efficacy

Four studies (n=289)[37, 38, 42, 54] assessed the associations between pain self-efficacy and trunk muscle strength, resulting in a significant pooled correlation coefficient of 0.22 (95% CI= 0.10, 0.33). Certainty of evidence was low.

3.4.3.4 Anticipated pain

In five studies (n=244),[2, 4, 16, 65, 66] participants were asked before the task to rate the LBP intensity they expected to feel during the actual test. The pooled correlation coefficient was -0.51 (95% CI= -0.77, -0.09). One study (n=33, r= -0.91)[2] was considered an influential case (e.g., based on large externally studentized residuals and Cook's distance),[87] which was also reflected in the wide 95% CI and a very large I^2-statistic of 92.4%. Removing this study confirmed its important influence, since removal resulted in a clearly smaller pooled correlation coefficient (4 studies, n= 211)[4, 16, 65, 66] of -0.34 (95% CI= -0.45, -0.21) and an I^2-statistic of 0%. Three studies (n=171),[4, 16, 66] not including the influential case, evaluated trunk muscle strength and this resulted in a pooled correlation coefficient of -0.37 (95% CI= -0.50, -0.23). Certainty of evidence was low to very low.

3.4.4 Sensitivity analyses

We repeated the same meta-analyses as described above (i.e., general analyses), but only with studies that had a low risk of bias on 'study confounding' and 'statistical analysis and reporting'. Fourteen studies (37%, n= 1048) that were conducted in a chronic LBP population could be included,[15, 16, 21-23, 37, 55, 67-69, 71, 85, 86, 88] which resulted in 11 separate sensitivity analyses for either pain-related fear of pain catastrophising (Table 4, forest plots are provided in supplementary appendix G). The results of the sensitivity analyses were very similar to the results from the general analyses. All pooled correlation coefficients were small (absolute r-values ≤ 0.25) and the absolute differences between pooled correlations of the general and sensitivity analyses were very small (i.e., differences in pooled r-values < 0.05), except for pain-catastrophising (general analysis pooled r= -0.18, sensitivity analysis pooled r= -0.25).

Nine studies (24%, n= 802)[16, 23, 31, 55, 67, 68, 71, 85] with low risk of bias on 'study confounding' and 'statistical analysis' additionally controlled for pain intensity (Table 5, forest plots are provided in supplementary appendix H). Sensitivity analyses including these studies could only be performed for the psychological factor pain-related fear. Again, pooled correlation coefficients were very similar to those of the general analysis, with differences in pooled r-values < 0.05.

Since the results of the sensitivity analyses did not change the conclusions of the general analyses, certainty of evidence was not further downgraded.

4. DISCUSSION

We performed a systematic review and meta-analysis to investigate the associations between pain-related psychological factors and maximal physical performance tests in patients with LBP. Very few studies were available for patients with (sub)acute LBP and recurrent LBP in remission, so it is difficult to draw conclusions for these populations. Regarding chronic LBP, higher levels of pain-related fear, pain catastrophising and anticipated pain were associated with worse maximal physical performance, whereas higher levels of pain self-efficacy were associated with a better physical performance. However, all pooled correlation coefficients were small and the majority ranged between 0.10 and 0.20, when expressed in absolute values. There was one exception, where anticipated pain was moderately associated with maximal physical performance. Overall, the certainty of evidence was low to moderate for pain-related fear when all questionnaires were combined and for the TSK-total score. For the other analyses, the certainty of evidence was low or very low.

Two previous reviews concluded that there was conflicting evidence regarding the relationships between psychological factors and physical performance in patients with LBP.[32, 82] However, these reviews did not perform a meta-analysis and also included psychological factors that do not specifically pertain to pain-related cognitions or emotions (e.g., general self-efficacy). Moreover, Van Abbema *et al*[82] only included studies investigating functional capacity, while Huijnen *et al*[32] also included submaximal performance tests. In addition, a significant number of studies have been available since previous reviews were published. Therefore, by specifically focusing on pain-related psychological factors and maximal physical performance, the current systematic review with meta-analysis significantly extends our knowledge regarding the relationship between these parameters in patients with LBP.

We conducted several subanalyses and sensitivity analyses to investigate the impact of study heterogeneity and the potential influence of personal factors and pain intensity. Overall, the magnitudes of pooled correlation coefficients of subanalyses and sensitivity analyses were similar to those obtained from the general analyses that included all types of maximal performance tests and questionnaires per psychological construct. The tests included in the subanalyses regarding the functional mobility category (e.g., stair climbing, bicycle ergometer) may be more variable compared to the other types of performance tests (e.g., trunk strength). In this respect, it should also be noted that we included walking tests at maximal speed in this category, since (maximal) walking tests have been shown to be valid measures of (maximal) performance in patients with LBP.[36] However, despite the apparent variability in test characteristics, meta-analyses regarding functional mobility had very low I^2-values (0% to 0.02%), showing there was negligible variability in the reported correlation coefficients. While this consistency in results of the subanalyses and sensitivity analyses adds to the robustness of our findings, certainty of evidence for some subanalyses was (very) low, which warrants for cautious interpretation. In addition, none of the studies included physical activity levels in their analyses, so it was not possible to perform a sensitivity analysis with studies taking this parameter into account.

In contrast to our hypothesis, lifting capacity was not associated more strongly with pain-related psychological factors as compared to most other tasks, despite the fact that patients with LBP typically perceive lifting as more harmful than other activities.[45, 50] A potential reason may be that patients were allowed to perform the lifting tasks in their habitual way in all of the included studies. Consequently, they could use their idiosyncratic safety behaviours to reduce their fear for the expected outcome (e.g., “I keep my back straight to prevent my disc from popping out.”). Disallowing these safety behaviours typically increases fear,[53] so under these conditions pain-related psychological factors may influence physical performance to a higher degree.

Although it has been hypothesised that pain-related psychological factors may have an important influence on physical performance,[8, 25, 46, 90] this was not supported by the small pooled correlation coefficients in our review. However, contextual factors deemed essential in this relationship may not have been properly accounted for in the included studies, which may explain this discrepancy, and which should be considered as a limitation of the current literature.

First, most studies used generic questionnaires (e.g., TSK) that only provide a general evaluation of a psychological construct, without questioning a person's beliefs regarding a specific task. For example, the TSK activity avoidance subscale only refers to fear for 'exercises' and 'being active'. However, some patients with LBP may not have a general fear of movement and actually consider exercises to be beneficial for their back, while they do believe that lifting objects or performing strenuous activities might be harmful. As such, the performance during a particular task may be better predicted by task-specific psychological assessments instead of generic questionnaires. Evidence emerging from studies investigating the relationships between task-specific pain-related (psychological) factors and movement behaviour (e.g., range of motion) supports this view.[40, 50, 92-94] In this context, it is interesting that anticipated pain intensity during the performance task was the only psychological factor that showed a moderate association with the actual performance. Clearly, this may be due to the psychological construct itself, but it may also indicate that task-specific pain-related psychological factors are stronger associated with maximal physical performance than generic measures.

Second, it has been well-established that motivation can influence physical performance.[51, 78] However, only four studies (11%) explicitly mentioned that participants were verbally encouraged during the performance task[4, 22, 23, 44] and none of the studies assessed the participants' motivation. In addition, none of the included studies (except one)[72] mentioned the actual reasons why participants stopped a test. Consequently, it is not known whether performances were limited by pain, physical exertion or other reasons. Notwithstanding, the behaviour of patients experiencing pain should be considered in the context of goal pursuit, a pivotal concept within various motivational frameworks.[14, 83, 84] During a physical performance task, a patient may be faced with two competing goals, i.e., performing well on the task versus avoiding pain. When a good performance is considered more important than the avoidance of pain, a person may persist despite the fear for pain and perform better than someone who prioritises pain control. As such, interindividual differences in motivation may potentially moderate the relationships between pain-related psychological factors and physical performance.[77, 81]

Finally, task familiarisation prior to the maximal performance test was only reported in twelve studies (32%),[5, 6, 15, 21-23, 31, 34, 37, 38, 44, 58] and studies reporting familiarisation either did not describe the familiarisation procedures or used inconsistent methods. For example, both the intensity (maximal vs. submaximal trials) or number of repetitions (single vs. multiple familiarisation trials) differed between studies. Since prior exposure to a task and the methods used for this exposure might influence patients' expectations and subsequent task performance,[13, 52] the heterogeneity of familiarisation procedures of the studies included in this review should be considered as a limitation.

Given the importance for the empirical validation of theoretical frameworks and the interpretation of outcomes on physical performance tests, future studies should take the abovementioned limitations of the current literature into account. It may be recommended to refrain from using only general questionnaires for assessing pain-related psychological factors, as they only showed small associations with maximal physical performance. This is in line with results from similar studies conducted in other chronic musculoskeletal conditions, such as knee osteoarthritis,[1, 9] femoroacetabular impingement[60] or whiplash associated disorders.[61] In addition, several recent systematic reviews reported associations of similar magnitude between psychological factors measured with generic questionnaires and movement behaviour (e.g., range of motion) in patients with LBP[11, 33] and peripheral joint conditions.[20] Instead, current theoretical models recommend to take contextual parameters into consideration and to identify a person's beliefs and motivation related to the task, in order to better understand an individual's behaviour and physical performance.[14, 84] Preliminary evidence from the current review and from studies investigating the relationships between psychological factors and spinal movement behaviour support this task-specific and person-centred approach.[40, 50, 94]

In summary, we performed a meta-analytic review to assess whether pain-related psychological factors are associated with maximal physical performance in patients with LBP. Our results showed that it is difficult to draw conclusions for (sub)acute and recurrent LBP due to the small number of available studies. Regarding chronic LBP, higher levels of pain-related fear, pain catastrophising and anticipated pain were associated with a worse maximal physical performance, while higher levels of pain self-efficacy were associated with better maximal physical performance. All pooled correlation coefficients were small, except for anticipated pain, which was moderately associated with maximal physical performance. Certainty of evidence was very low to moderate for pain-related fear, and very low to low for the other pain-related psychological factors.

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Contributors

Study design and conceptualisation: TM, LDB, LJ and NG. Acquisition, analysis and interpretation of data: all authors. Manuscript draft: TM and LDB. Critical revision of the manuscript: all authors.

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Figure legends

Figure 1 – PRISMA flowchart

Table legends

Table 1 - Summary of study characteristics

Table 2 - Risk of bias

Table 3 - Meta-analyses of associations between pain-related factors and maximal physical performance in chronic low back pain

Table 4 - Sensitivity analyses including studies controlling for personal factors

Table 5 - Sensitivity analyses including studies controlling for personal factors and pain intensity

Supplementary appendix A – detailed search strategy per database

Pubmed

((Back pain[Title/Abstract] OR low back pain[Title/Abstract] OR lower back pain[Title/Abstract] OR backache[Title/Abstract] OR sciatic*[Title/Abstract] OR lumbago[Title/Abstract] OR low back pain[MeSH] or Back pain[MeSH])

AND

(Performance[Title/Abstract] OR functional capacity[Title/Abstract] OR aerobic capacity[Title/Abstract] OR exercise capacity[Title/Abstract] OR work capacity[Title/Abstract] OR torque[Title/Abstract] OR torque[MeSH] OR strength[Title/Abstract] OR force[Title/Abstract] OR muscle strength[MeSH] OR speed[Title/Abstract] OR velocity[Title/Abstract] OR VO2-max[Title/Abstract] OR VO2max[Title/Abstract] OR maximal oxygen consumption[Title/Abstract] OR TUG[Title/Abstract] OR timed-up-and-go[Title/Abstract] OR sit-to-stan*[Title/Abstract] OR cardiopulmonary test[Title/Abstract] OR maximal inspiratory pressure[Title/Abstract] OR maximal expiratory pressure[Title/Abstract] OR walking[Title/Abstract] OR gait[Title/Abstract] OR gait[MeSH] OR exercise test[Title/Abstract] OR exercise test[MeSH] OR isokinetic*[Title/Abstract] OR isometric*[Title/Abstract] OR isotonic*[Title/Abstract] OR ergometry[Title/Abstract] OR ergometry[Title/Abstract] OR treadmill test[Title/Abstract] OR bicycle test[Title/Abstract] OR exertion*[Title/Abstract] OR biering-Sörensen[Title/Abstract] OR lifting[Title/Abstract] OR lifting[MeSH] OR physical fitness[Title/Abstract] OR physical fitness[MeSH] OR physical test*[Title/Abstract] OR functional capacity evaluation[Title/Abstract] OR Progressive Isoinertial Lifting Evaluation[Title/Abstract]))

AND

(fear*[Text Word] OR fear[MeSH] OR catastroph*[Text Word] OR anxiety[Text Word] OR anxiety[MeSH] OR hypervigilan*[Text Word] OR avoidan*[Text Word] OR coping[Text Word] OR belief*[Text Word] OR perception*[Text Word] OR kinesiophob*[Text Word] OR expectation*[Text Word] OR cognition*[Text Word] OR emotion*[Text Word] OR emotions[MeSH] OR harmful*[Text Word] OR attention*[Text Word] OR pain-related fear[Text Word] OR fear of movement[Text Word] OR fear of pain[Text Word] OR self-efficacy[Text Word] OR psychological[Text Word] OR psychosocial[Text Word])

Web of Science

TOPIC: “Back pain” OR “low back pain” OR “lower back pain” OR “backache” OR “sciatic*” OR “lumbago”

AND

TOPIC: “Performance” OR “functional capacity” OR “aerobic capacity” OR “exercise capacity” OR “work capacity” OR “torque” OR “strength” OR “force” OR “muscle strength” OR “speed” OR “velocity” OR “VO2-max” OR “VO2max” OR “maximal oxygen consumption” OR “TUG” OR “timed-up-and-go” OR “sit-to-stan*” OR “cardiopulmonary test” OR “maximal inspiratory pressure” OR “maximal expiratory pressure” OR “walking” OR “gait” OR “exercise test” OR “isokinetic*” OR “isometric*” OR “isotonic*” OR “ergometry” OR “treadmill test” OR “bicycle test” OR “exertion*” OR “biering-Sörensen” OR “lifting” OR “physical fitness” OR “physical test*” OR “functional capacity evaluation” OR “Progressive Isoinertial Lifting Evaluation”

AND

TOPIC: “fear*” OR “catastroph*” OR “anxiety” OR “hypervigilan*” OR “avoidan*” OR “coping” OR “belief*” OR “perception*” OR “kinesiophob*” OR “expectation*” OR “cognition*” OR “emotion*” OR “harmful*” OR “attention*” OR “pain-related fear” OR “fear of movement” OR “fear of pain” OR “self-efficacy” OR “psychological” OR “psychosocial”

LIMITS

WoS Core Collection

Category: articles

CINAHL
AB “Back pain” OR “low back pain” OR “lower back pain” OR “backache” OR “sciatic*” OR “lumbago”

AND

AB “Performance” OR “functional capacity” OR “aerobic capacity” OR “exercise capacity” OR “work capacity” OR “torque” OR “strength” OR “force” OR “muscle strength” OR “speed” OR “velocity” OR “VO2-max” OR “VO2max” OR “maximal oxygen consumption” OR “TUG” OR “timed-up-and-go” OR “sit-to-stan*” OR “cardiopulmonary test” OR “maximal inspiratory pressure” OR “maximal expiratory pressure” OR “walking” OR “gait” OR “exercise test” OR “isokinetic*” OR “isometric*” OR “isotonic*” OR “ergometry” OR “treadmill test” OR “bicycle test” OR “exertion*” OR “biering-Sörensen” OR “lifting” OR “physical fitness” OR “physical test*” OR “functional capacity evaluation” OR “Progressive Isoinertial Lifting Evaluation”

AND

AB “fear*” OR “catastroph*” OR “anxiety” OR “hypervigilan*” OR “avoidan*” OR “coping” OR “belief*” OR “perception*” OR “kinesiophob*” OR “expectation*” OR “cognition*” OR “emotion*” OR “harmful*” OR “attention*” OR “pain-related fear” OR “fear of movement” OR “fear of pain” OR “self-efficacy” OR “psychological” OR “psychosocial”

Embase

Tiab kw “Back pain” OR “low back pain” OR “lower back pain” OR “backache” OR “sciatic*” OR “lumbago”

AND

Tiab kw AB “Performance” OR “functional capacity” OR “aerobic capacity” OR “exercise capacity” OR “work capacity” OR “torque” OR “strength” OR “force” OR “muscle strength” OR “speed” OR “velocity” OR “VO2-max” OR “VO2max” OR “maximal oxygen consumption” OR “TUG” OR “timed-up-and-go” OR “sit-to-stan*” OR “cardiopulmonary test” OR “maximal inspiratory pressure” OR “maximal expiratory pressure” OR “walking” OR “gait” OR “exercise test” OR “isokinetic*” OR “isometric*” OR “isotonic*” OR “ergometry” OR “treadmill test” OR “bicycle test” OR “exertion*” OR “biering-Sörensen” OR “lifting” OR “physical fitness” OR “physical test*” OR “functional capacity evaluation” OR “Progressive Isoinertial Lifting Evaluation”

AND

Tiab kw AB “fear*” OR “catastroph*” OR “anxiety” OR “hypervigilan*” OR “avoidan*” OR “coping” OR “belief*” OR “perception*” OR “kinesiophob*” OR “expectation*” OR “cognition*” OR “emotion*” OR “harmful*” OR “attention*” OR “pain-related fear” OR “fear of movement” OR “fear of pain” OR “self-efficacy” OR “psychological” OR “psychosocial”

Supplementary Appendix B – QUIPS risk of bias procedures

Domain	*Assessed for review?*	*Risk assessment*
1. Study Participation		
The source population or population of interest is adequately described for key characteristics.	Yes	Low bias: no items poorly reported Moderate bias: 1 or 2 items poorly reported, and baseline characteristics had to be adequately reported High bias: >2 items poorly reported, or poor reporting of baseline characteristics Adequate reporting of baseline characteristics: age, sex, pain intensity and disability had to be reported.
The sampling frame and recruitment are adequately described, including methods to identify the sample sufficient to limit potential bias	Yes	
Period of recruitment is adequately described	Yes	
Place of recruitment (setting and geographic location) are adequately described	Yes	
Inclusion and exclusion criteria are adequately described	Yes	
There is adequate participation in the study by eligible individuals	Yes	
The baseline study sample is adequately described for key characteristics.	Yes	
2. Study Attrition		
Response rate is adequate.	Yes	Low bias: data of >80% of participants available for analysis High bias: data of <80% of participants available for analysis Some items were not assessed because we only included cross-sectional data (including baseline data of longitudinal studies and RCTs)
Attempts to collect information on participants who dropped out	No	
Reasons for loss to follow-up are provided.	No	
Participants lost to follow-up are adequately described for key characteristics.	No	
There are no important differences between key characteristics and outcomes in participants who completed the study and those who did not.	No	
3. **Psychological Factor Measurement**		
Definition of the Psychological factor	Yes	Low bias: no items poorly reported Moderate bias: 1 or 2 items poorly reported, but adequate definition of the psychological factor High bias: >2 items poorly reported, or poor definition of the psychological factor For adequate definition of the psychological factor, a reference to an available questionnaire should be provided, or the measurement should be adequately described in the report itself.
Valid and Reliable Measurement of Psychological	Yes	
Continuous variables are reported or appropriate cut-points are used.	Yes	
The method and setting of measurement of PF is the same for all study participants.	Yes	
Adequate proportion of the study sample has complete data for PF variable.	Yes	

Appropriate methods of imputation are used for missing data.	No	
4. Outcome measurement		
A clear definition of outcome is provided	Yes	**Low bias**: no items poorly reported **Moderate bias**: 1 item poorly reported, but adequate definition of the outcome measurement **High bias**: >1 item poorly reported, or poor definition of the outcome measurement For adequate definition of the outcome measurement, a reference to the outcome measurement should be provided, or the outcome measurement should be adequately described in the report itself
Valid and Reliable Measurement of Outcome	Yes	
The method and setting of measurement of the outcome is the same for all study participants. .	Yes	
5. Study Confounding		
Important Confounders Measured	Yes	**Low bias**: no items poorly reported **Moderate bias**: 1 or 2 items poorly reported, or moderate accounting for confounding factors **High bias**: >2 items poorly reported, or poor accounting for confounding factors Accounting for confounding factors: age, sex and bodyweight Adequate: ≥ 2 factors taken into account Moderate: 1 factor taken into account Poor: no factor taken into account Taking these factors into account may have been done by setting specific inclusion criteria (e.g., only inclusion of male participants), by adjusting the task (e.g., different starting weight based on sex) or in the statistical analyses.
Clear definition of the confounding factors	Yes	
Valid and Reliable Measurement of confounders	Yes	
Method and Setting of Confounding Measurement the same for all participants	Yes	
Appropriate methods used for missing data imputation	No	
Important confounders are accounted for in the study design	Yes	
Important potential confounders are accounted for in the analysis	yes	
6. Statistical Analysis and Reporting		
There is sufficient presentation of data to assess the adequacy of the analysis.	Yes	**Low bias**: no items poorly reported **Moderate bias**: 1 or 2 items poorly reported **High bias**: >2 items poorly reported
The strategy for model building is appropriate	Yes	
The selected statistical model is adequate for the design of the study.	Yes	
There is no selective reporting of results.	Yes	

Overall rating of the study		Low risk of bias: At least 4/6 domains with low risk, including the domains ‘study confounding’ and ‘statistical analysis and reporting’. High risk of bias: When studies did not fulfil the criteria for low risk of bias.

Supplementary appendix C – Detailed characteristics of included studies

Study	Participants	Clinical participant characteristics	Performance task	Type of performance task	Pain-related psychological factor	Performance adjusted for bodyweight, age, sex or pain intensity?	Motivated during test?	Familiarisation?
Al-Obaidi *et al*, 2000	CLBP, N= 63 (46% female), mean age= 36.3y (SD= 8.5y).	Pain intensity= 84.4/100 (SD= 11.6), RMDQ= 16.1 (SD= 7.0), FABQ-W= 30.7 (SD= 9.8), FABQ-PA= 21.3 (SD= 3.1), onset LBP= 10.3 m (SD= 7.2m)	Isometric lumbar extensor strength, at 7 lumbar spine angles: 0°, 12°, 24°, 36°, 48°, 60°, and 72°. Participants were seated on a machine, with feet supported.	Trunk muscle strength	Pain-related fear (FABQ-PA & FABQ-W); anticipated pain (0-100mm VAS)	No	Verbally	?
Al-Obaidi *et al*, 2003	CLBP, N= 31 (48% female), mean age= 36.1y (SD= 8.1y)	RMDQ= 14.1 (SD= 7.7); FABQ-PA= 18.3 (SD= 5.0); FABQ-W= 19.6 (SD= 10.3)	10m walk as fast as possible	Functional mobility	Pain-related fear (FABQ-PA & FABQ-W); anticipated pain (0-100mm VAS)	No	?	?
Al-Obaidi *et al*, 2005	CLBP, activity limiting. N=42 (48% female), mean age =45.0y (SD= 6.2y).	Pain intensity= 7.6/10 (SD= 1.2), FABQ-PA= 21.5 (SD= 5.4), FABQ-W= 33.9 (SD= 13.4), onset LBP= 4.9m (SD= 2.2m)	Isometric lumbar extensor strength tested at 7 lumbar spine angles: 0°, 12°, 24°, 36°, 48°, 60°, and 72°. Participants were seated on a machine, with feet supported.	Trunk muscle strength	Pain-related fear (FABQ-PA & FABQ-W)	No	?	?
Applegate *et al*, 2018	History of recurrent LBP (>1 episode of LBP in past 6m). Exclusion if pain episode in past 6w with NPRS >3/10. N=24 (50% female), age= 24.3y (SD= 1.5y).	PCS= 32.0 (SE= 1.3); Pain resilience scale= 6.8 (SE= 0.9); TSK-17= 44.5 (SE= 3.2)	Virtual reality Biering-Sorensen test with head mounted display. Participants had to fly through hoops by keeping the extended position.	Trunk muscle endurance	Pain catastrophising (PCS), Pain resilience (Pain resilience Scale), pain-related fear (TSK-17)	Bodyweight	Not verbally, a virtual reality game was used	<5s in test position, and participants performed the test without virtual reality 1-2 weeks prior to test
Applegate *et al*, 2019	History of recurrent LBP (>1 episode of LBP in past 6m). Exclusion if pain episode in past 6w with NPRS >3/10. N=24 (50% female), age= 24.3y (SD= 1.5y).	PCS= 32.0 (SE= 1.3); Pain resilience scale= 6.8 (SE= 0.9); TSK-17= 44.5 (SE= 3.2)	Biering-Sorensen test: Trunk off a table (facing down) with legs strapped to the table. Staying in a horizontal trunk position as long as possible.	Trunk muscle endurance	Pain catastrophising (PCS), Pain resilience (Pain Resilience Scale), pain-related fear (TSK-17)	Bodyweight	?	<5 secs in test position

Study	Participants	Clinical participant characteristics	Performance task	Type of performance task	Pain-related psychological factor	Performance adjusted for bodyweight, age, sex or pain intensity?	Motivated during test?	Familiarisation?
Crombez *et al*, 1998	CLBP, N=49 (% female?), age= 39.7y (SD= 7.5y).	Avoider and confronter subgroups based on Leuven back questionnaire containing questions about 10 back straining movements. Onset LBP= 74.5m (SD= 88m).	Isokinetic knee extension & flexion (180°/s).	Peripheral muscle strength	Pain-related fear (Leuven back questionnaire), Anticipated pain.	Sex, age and bodyweight	?	A few submaximal trials.
Crombez *et al*, 1999	Study 1: CLBP, N=38 (66% female), age= 40.8y (SD= 7.7y). Study 2: CLBP, N= 31 (25% female), age= 41.6y (SD= 10.7y).	Study 1: Onset LBP= 6.4y (SD= 7.7y). Study 2: RMDQ= 13.6 (SD= 4.3); PASS= 60.7 (SD=26); PCS= 21.7 (SD= 9.9); current pain intensity= 5.7 (SD= 2.4), onset LBP= 10.1y (SD= 8.9y)	Study 1: Isokinetic trunk flexion and extension in seated position (60°/sec). Study 2: Lifting a 5.5kg bag with the dominant arm in a standing position until pain or discomfort urged patients to stop the task.	Study 1= trunk muscle strength. Study 2= lifting capacity.	Study 1= pain-related fear (TSK-17, FABQ-W, FABQ-PA), anticipated pain. Study 2= pain-related fear (PASS), pain catastrophising (PCS).	Age, sex, bodyweight and baseline pain intensity	?	?
Demoulin *et al*, 2013	CLBP, N= 50 (50% female), age= 44.2y (SD= 9.5y).	Pain intensity= 40.5/100 (SD= 20); RMDQ= 9.3 (SD= 4.1); PCS= 27.9 (SD= 9.6); TSK-total= 40.9 (SD= 7.0); TSK-AA= 20.1 (SD= 4.1); PHODA-SeV= 46.3 (SD= 13.5); FVAS Biering-Sorensen test= 0 (0 to 35), onset LBP= 9.2y (9.8y)	Isometric trunk strength in seated position on a machine, Biering-Sorensen test	Trunk muscle strength, trunk muscle endurance	Pain-related fear (TSK-total, TSK-AA, PHODA-SeV, VAS-scale (0-100) where patients assessed how afraid they were to perform the physical tests).	Bodyweight for trunk muscle strength	?	Yes, not specified how.
Fehrman *et al*, 2017	CLBP: Two subgroups of a larger cohort (N= 178, 50% female) based on the AEQ: Avoiders (N= 33) and adaptive responders (N= 34). Means for total group (N=178): age= 46.8y (SD= 16.3y). duration LBP= 128.1m (SD= 123.3m)	Mans for total group (N= 178): pain-intensity past 3m= 51.5/100 (SD= 13.2), current pain intensity= 28.5/100 (SD= 18.8), RMDQ= 6.5 (SD= 3.8); PDI= 15.8 (SD= 10.9), onset LBP= 128.1m (SD= 123.3m)	Isometric lumbar extensor strength on an isokinetic device. Patients were seated with 30° forward trunk inclination relative to vertical plane.	Trunk muscle strength	Pain-related fear (AEQ)	No	Verbally	Yes, not specified how.

Study	Participants	Clinical participant characteristics	Performance task	Type of performance task	Pain-related psychological factor	Performance adjusted for bodyweight, age, sex or pain intensity?	Motivated during test?	Familiarisation?
Goubert *et al*, 2005	CLBP, N= 84 (52.4% female), age= 40.3y (SD= 11.1y).	Pain intensity= 2.5/10; PCS= 22.5 (SD= 10.5); TSK-13= 31.1 (SD= 7.2), LBP onset= 59.9m (SD= 82.8m)	Trunk flexion-extension on isokinetic dynamometer in standing position: (60°/s), ROM from upright to 80° flexion.	Trunk muscle strength	Pain-related fear (TSK-13), pain-catastrophising (PCS)	Age, sex, baseline pain intensity	Verbally	3 submaximal and 1 maximal repetition(s)
Huijnen *et al*, 2010	Nonspecific (sub)acute LBP 4-7 weeks after onset. N= 124 (47% female), age= 44.1y (SD= 10.3y).	TSK-17= 36.02 (SD= 7.6); QBPDS= 40.64 (SD= 17.7)	Isometric quadriceps strength of preferred leg, seated on fixed isokinetic dynamometer.	Extremity muscle strength	Pain-related fear (TSK-17)	Age, sex, bodyweight	Not verbally, participants could see the force produced on a screen	1 maximal attempt
Ishak *et al*, 2017	Mainly chronic nonspecific LBP: 17% acute LBP; 16% subacute LBP; 67% CLBP, N= 63 (% female ?), age= 70.9y (SD= 7.9y).	Pain= 4.2/10 (SD= 1.7); TSK-11= 29.7 (SD= 7.9); TSK-11-AA= 16.0 (SD= 4.33); TSK-11-SF= 13.89 (SD= 4.32)	Isometric lumbar extension strength in prone & Isometric abdominal strength in crook lying, both measured with a mechanical dynamometer; Hand-grip strength using a hand-held dynamometer at the dominant hand. Patients were seated with elbows in 90° flexion.	Trunk muscle strength, extremity muscle strength	Pain-related fear (TSK-11-total)	No	?	For trunk strength (not specified how)
Kaivanto *et al*, 1995	CLBP with or without nerve root impairment. N=105 (44% female).	Onset LBP= 4.7y (range= 0.5y to 30y)	Trunk flexion-extension on isokinetic dynamometer in standing position: 5 reps at 50°/s; 5 reps at 100°/s; 20 reps at 150°/s.	Trunk muscle strength	Pain self-efficacy (PSEQ)	Sex, age and bodyweight	?	Yes, not specified how.
Keller *et al*, 1999	CLBP, N= 105 (62% Female), age= 40.2y (SD= 11.3y). 68% was on sick leave	Pain-self efficacy on 1 (low) to 7 (high) scale. Men= 3.8 (SD= 1.3), women= 3.7 (SD= 1.7), onset LBP= 2.2y (range= 3m to 10y).	Isokinetic trunk flexion and extension in a standing position. 4 reps at 60°/sec; 2 reps at 120°/sec. Total work for both speeds was calculated.	Trunk muscle strength	Pain self-efficacy	Age, sex, pain intensity during performance test	?	Yes, not specified how.

Study	Participants	Clinical participant characteristics	Performance task	Type of performance task	Pain-related psychological factor	Performance adjusted for bodyweight, age, sex or pain intensity?	Motivated during test?	Familiarisation?
Kernan *et al*, 2007	CLBP, ODI >20/100. N= 63 (56% female), age= 43y (SD= 10y) Mean duration= 28m (SD= 23m).	Pain intensity= 5.8/10 (SD= 2.2), ODI= 38.7/100 (SD= 13.0), TSK-17= 41.8 (SD= 7.7); FABQ-PA= 14.4 (SD= 5.6); FABQ-W= 20.5 (SD= 13.0).	Back extension strength on an isokinetic dynamometer. Progressive lifting capacity with the cervical and lumbar parts of PILE.	Trunk muscle strength, lifting capacity	Pain-related fear (TSK-total, FABQ-PA, FABQ-W).	No	?	?
La Touche *et al*, 2019	CLBP, N= 49 (76% female)	RMDQ= 8.7 (SD= 3.4); PCS= 20.2 (SD= 10.1); TSK-11= 27.6 (SD= 6.2); Chronic pain self-efficacy scale= 138.4 (SD= 28.8)	Isometric back lumbar extensors strength using a standing digital back muscle dynamometer: patients stood with extended knees and had to bend forward until the index finger reached the knee cap, elbows extended. From this position, they had to pull a bar by trying to make a lumbar extension movement.	Trunk muscle strength	Pain-related fear (TSK-11), pain catastrophising (PCS), pain self-efficacy (CPSS)	No	?	?
Lackner *et al*, 1996	CLBP, N= 85 (42% female), age= 37y (range= 21-63y)	Median onset LBP 12.7m (range= 2.5m to 252m)	Progressive lifting capacity: lifting a tray from the floor to waist level and waist to eye level. Gradual increase of weight; Trunk strength: maximal bilateral pull of, or bilateral push against a bar in a standing position; Functional mobility: carrying a tray during walking 15.24 metres. Progressive increase of weight until maximum is reached.	Lifting capacity, trunk muscle strength, functional mobility.	Pain-related fear (Functional Reinjury-Pain expectancy Scales: assessment of the likelihood that performance of certain activities cause pain and reinjury.)	Sex, pain intensity	?	?
Lariviere *et al*, 2003	NSCLBP, N= 41 (all males), age= 33y (SD= 12y);	Pain intensity= 23/100 (SD= 24), ODI= 18 (SD= 12); FABQ-W= 10 (SD= 7), FABQ-PA= 14 (SD= 14), onset LBP= 76m (SD= 109m)	Isometric back extension against a dynamometer in a standing position, with knees extended.	Trunk muscle strength	Pain-related fear (FABQ-W, FABQ-PA).	Sex (all male participants)	Verbally	Yes, not specified how.

Study	Participants	Clinical participant characteristics	Performance task	Type of performance task	Pain-related psychological factor	Performance adjusted for bodyweight, age, sex or pain intensity?	Motivated during test?	Familiarisation?
Nieto-Garcia *et al*, 2019	CLBP, N= 30 (47% female), age= 49.3y (SD= 11.4y). Participants participated in at least 1 exercise session per week.	RMDQ= 4.5 (SD= 2.9); PCS= 12.1 (SD= 8.5); TSK-11= 25.6 (SD= 5.7); TSK-11-AA= 15.7 (SD= 3.7); TSK-11-SF= 9.9 (SD= 2.8); CPSS= 149.2 (SD= 21.4)	Isometric pull using a dynamometer: participants stood with 110° knee flexion, and held a bar attached to a chain in both hands with elbows extended. Participants had to pull the bar upwards as hard as possible using back muscles.	Trunk muscle strength.	Pain-related fear (TSK-11 and subscales), pain catastrophising (PCS and subscales), Pain self-efficacy (CPSS and subscales)	No	?	?
Oesch *et al*, 2012	CLBP, N= 126 (25.4% female), age= 44.1y (SD= 10.4y).	Pain intensity= 5.1/10 (SD= 2.2); Disability (Spinal Function Sort)= 96/200 (SD= 50.9) - higher score = better; FABQ-W= 32.7 (SD= 10.4)	Incremental lifting capacity (Isernhagen-protocol) floor-to waist; 6-minute walking test as far as possible (30m track); hand-grip strength with dynamometer	Lifting capacity, functional mobility, peripheral muscle strength	Pain-related fear (FABQ-W)	Age, sex, baseline pain intensity pain	?	?
Pagé *et al*, 2015	CLBP, N= 53 (43% female), age= 44.1y (SD= 13.3y). Duration of LBP= 130.7 months (SD= 112 months)	Pain intensity= 2.3/10 (SD= 2.3), ODI= 18.8 (SD= 10.3), TSK-17= 36.4 (SD= 8.8)	Maximal isometric trunk strength and endurance on a 30° inclined Roman chair with a strap around the chest that was connected to a cable. Two positions were tested: lumbar extensors and in a lateral (sideways) position.	Trunk muscle strength, trunk muscle endurance	Pain-related fear (TSK)	No	Not verbally, participants saw a screen with %MVC they had to maintain	MVC measured in same position before the test
Papciak *et al*, 1991	CLBP, N= 186 (all males). On sick leave > 3 months.	?	Isokinetic trunk flexion/extension on dynamometer at 30°/s. Patients were in a standing position with slightly bent knees.	Trunk muscle strength	Pain catastrophising (pain catastrophising subscale of Coping strategies questionnaire)	Sex (all male participants), bodyweight.	?	Yes, not specified how.

Study	Participants	Clinical participant characteristics	Performance task	Type of performance task	Pain-related psychological factor	Performance adjusted for bodyweight, age, sex or pain intensity?	Motivated during test?	Familiarisation?
Rainville *et al*, 1992	CLBP, N= 40 (15% female), age= 37y (SD= 10y). Mean duration of LBP= 17 months (SD= 12)	Pain intensity= 6.7/10 (SD= 1.9), anticipated pain scores: PILE lumbar= 3.1/10 (SD= 0.8); PILE cervical= 2.9/10 (SD= 1.0); Bicycle test= 2.6/10 (SD= 1.1); Arm ergometer= 2.5/10 (SD= 1.2). Onset LBP= 17m (SD= 12m)	Progressive inertial lifting evaluation (PILE) from floor to waist, and waist to overhead position, bicycle and arm ergometer: progressive protocol at 60 cycles/minute.	Lifting capacity, functional mobility	Anticipated pain	Sex for lifting capacity: different weights (and increments in weights) for men and women	?	?
Rainville *et al*, 2004	CLBP, N=70 (55% female), age= 43y (SD= 10y), ODI >20%.	Mean pain intensity= 5.8 (SD= ?), ODI= 38% (SD= ?), onset LBP= 24m (SD= 22m).	Progressive inertial lifting evaluation (PILE) from floor to waist, and waist to overhead position, back extension strength on isokinetic dynamometer.	Lifting capacity, trunk muscle strength	Anticipated pain	bodyweight	?	?
Reneman *et al*, 2003	CLBP, N= 64 (16% female), age= 38y (SD= 8.9).	Pain intensity= 5.1/10 (SD= 2.1), TSK-17= 41.6 (SD= 7.3), onset LBP= 9.8m (SD= 11.3m).	Pogressive lifting (Isernhagen): Lifting a weight from to floor to a table 5 times in 90 seconds. The weight was gradually increased, until the maximal weight was reached.	Lifting capacity	Pain-related fear (TSK-17)	Sex	no	?
Reneman *et al*, 2007	Study 1: CLBP, N= 79 (38% female), age= 37.8y (SD= 8.9y). Study 2: CLBP, N= 58 (33% female), age= 38.8y (SD= 8.5y)	Study 1: Pain intensity= 4.9/10 (SD= 2.1), RMDQ= 12.5 (SD= 4.5), TSK-17= 36.9 (SD= 5.4). Study 2: Pain intensity= 4.6/10 (SD= 2.3); RMDQ= 11.5 (SD= 4.9); FABQ-PA= 13.3 (SD= 4.6); FABQ-W= 17.9 (SD= 10.2)	Study 1 and 2: 3 items from the Isernhagen Work Systems functional capacity test. Progressive isoinertial lifting; Static bending capacity (kg): to stand as long as possible in 30-60° forward bend, while performing a simple manipulation task; Dynamic bending task: Pick up a small object from the floor and place it on a shelf level with the top of the head. This was repeated 20 times as fast as possible.	Study 1 and 2: Lifting capacity, trunk muscle endurance	Study 1 and 2: Pain-related fear (study 1= TSK-17. Study 2= FABQ-PA, FABQ-W)	Study 1 and 2: Sex, age, pain intensity	?	?

Study	Participants	Clinical participant characteristics	Performance task	Type of performance task	Pain-related psychological factor	Performance adjusted for bodyweight, age, sex or pain intensity?	Motivated during test?	Familiarisation?
Roelofs *et al*, 2004	CLBP, N= 31 (25% female), age= 41.6y (SD= 10.7y).	RMDQ= 13.6 (SD= 4.3), TSK= 40 (range= 24 to 49), onset LBP= 10.1y (SD= 8.9y).	Lifting task: lift a 5.5kg bag with the dominant arm and hold it until pain or discomfort urged them to stop. Progressive stationary bicycle task until pain or discomfort urged them to stop.	Lifting capacity, functional mobility	Pain-related fear (TSK-17, TSK-AA, TSK-SF). Only results of the subscales were included in the analysis, as results for the TSK-total scores were reported in Vlaeyen (1995).	No	no	?
Schiphorst *et al*, 2008	CLBP, N= 92 (35% female), age= 38.5y (SD= 8.7y).	TSK-17= 36.4 (SD= 5.6), onset LBP= 52w (IQR= 24w to 150m)	Study 1 and 2: 3 items from the Isernhagen Work Systems functional capacity test. Progressive isoinertial lifting; Static bending capacity (kg): to stand as long as possible in 30-60° forward bend, while performing a simple manipulation task; Dynamic bending task: Pick up a small object from the floor and place it on a shelf level with the top of the head. This was repeated 20 times as fast as possible.	Lifting capacity, trunk muscle endurance	Pain-related fear (TSK-17)	No	?	?

Study	Participants	Clinical participant characteristics	Performance task	Type of performance task	Pain-related psychological factor	Performance adjusted for bodyweight, age, sex or pain intensity?	Motivated during test?	Familiarisation?
Smeets *et al*, 2007	CLBP, N= 221 (47.5% female), age= 41.6y (SD= 9.9y).	Pain intensity= 4.9/10 (SD= 2.5), RMDQ= 13.8 (SD= 3.8), TSK-17= 38.9 (SD= 6.9), onset LBP= 56.7m (SD= 72.3m)	Five-minute walking test: walk as fast as possible for 5 minutes (30m distance), Fifty-foot walking test: walk as fast as possible over 50ft over an 8-shaped circuit , Sit to stand test: perform 5 times as fast as possible from a chair without arms, Loaded forward reach: reach as far as possible holding a stick of 4.5 kg at shoulder height; One-minute stair climbing test: walking up and down stairs as fast as possible, Progressive isoinertial lifting (PILE): lift a box 4 times in 20s from the floor to a table. The weight was gradually increased.	Lifting capacity, functional mobility	Pain-related fear (TSK-17). Data for pain catastrophising could not be retrieved.	Sex, age, current pain intensity	?	?
Soer *et al*, 2006	CLBP, N= 53 (40% female), age= 38.5y (SD= 9.8y).	RMDQ= 9.2 (SD= 5.5), TSK= 35.9 (SD= 7.0), FABQ-PA= 13.7 (SD= 5.0), FABQ-W= 17.3 (SD= 9.7), onset LBP= 308w (SD= 445w).	2 different lifting capacity tasks: progressive isoinertial lifting evaluation (PILE): 4 lifts from table to floor and vice versa within 20 s. Gradual increase of weights. WorkWell Sysytems functional capacity evaluation (Isernhagen-protocol): 5 lifts from table to floor vice versa within 90 s. 4 to 5 weight increments were used to reach maximum lifted weight.	Lifting capacity	Pain-related fear (TSK-17, FABQ-PA, FABQ-W).	No	?	?

Study	Participants	Clinical participant characteristics	Performance task	Type of performance task	Pain-related psychological factor	Performance adjusted for bodyweight, age, sex or pain intensity?	Motivated during test?	Familiarisation?
Thibodeau *et al*, 2013	CLBP due to a motor vehicle or workplace accident. N= 78 (37% female), age= 40.6 (SD= 9.28).	McGill pain-rating index= 23.9 (SD=13.2), Dallas pain questionnaire (disability= 54.2 (SD= 21.8), Pain-related anxiety (PASS-20)= 32.8 (SD= 19.5), onset LBP= 20m (SD= 54m)	Progressive isoinertial lifting (PILE): lift a box 4 times in 20s from the floor to a table. The weight was gradually increased.	Lifting capacity	Pain-related fear (PASS)	Sex	?	?
Thomas *et al*, 2008	CLBP, N= 20 (55% female), age= 23.9y (SD= 7.4y).	McGill pain Questionnaire= 2.1/5 (SD= 0.9); RMDQ= 7.0 (SD= 3.6), onset LBP= 3.2y (SD= 2.9y).	Isometric maximal pull into flexion, extension and rotation left and right with trunk attached to a cable. Patients were in partial kneeling position (support under ischial tuberosities & shins).	Trunk muscle strength	Pain-related fear (PASS)	Pain intensity	?	?
Verbrugghe *et al*, 2020	CLBP, N=101 (62% female), age= 44.2y (SD=9.6y).	Pain intensity= 5.7/10 (SD= 1.6), mODI= 21.1% (SD= 10.1 %), TSK-17= 34.0 (SD= 6.1), onset LBP= 12.0y (SD= 8.8y)	Isometric lumbar extensor and abdominal strength. Patients were seated in an isokinetic dynamometer. Progressive cycle ergometer protocol.	Trunk muscle strength, functional mobility	Pain-related fear (TSK-17)	Age, sex, bodyweight (for muscle strength), pain intensity.	?	?
Verbunt *et al*, 2005	CLBP, N= 25 (40% female), age= 42.7y (SD= 9.5y).	Pain intensity= 4.3/10 (SD= 2.6), RMDQ= 15.3 (SD=4.5), TSK-17= 39.9 (SD= 6.5), PCL-catastrophising subscale= 42.3 (11.8), onset LBP= 9.9y (SD= 8.3y)	Isometric quadriceps muscle strength of the Quadriceps muscle of the preferred leg in seated position on an isokinetic dynamometer.	Peripheral muscle strength	Pain-related fear (TSK-17), pain catastrophising (PCL - pain catastrophising subscale)	Sex, bodyweight	Not verbally, visual feedback about produced force.	?
Vincent *et al*, 2013	CLBP, obese persons. N= 55 (60% female), age= 67y (SD= 6.6y).	ODI= 29% (SD= 12.4), RMDQ= 9.4 (SD= 4.2), TSK-11= 22.9 (SD= 6.8)	Progressive treadmill walking protocol until exhaustion or pain limitation.	Functional mobility	Pain-related fear (TSK-11).	Age, sex, bodyweight	?	?

Study	Participants	Clinical participant characteristics	Performance task	Type of performance task	Pain-related psychological factor	Performance adjusted for bodyweight, age, sex or pain intensity?	Motivated during test?	Familiarisation?
Vlaeyen *et al*, 1995	CLBP, N= 33 (76% female), age= 42.4y (SD= 9.7y).	TSK-17= 35.8 (SD= 7.4), onset LBP= 10.3y (SD= 10.1y)	Lifting a 5.5kg bag with the dominant arm and hold it until pain or physical discomfort made it impossible to continue.	Lifting capacity	Pain-related fear (TSK-17).	No	?	?

When motivation or familiarisation were not reported, this was indicated with a question mark (?). Time since onset of low back pain is indicated in years (y), months (m) or weeks (w).

CLBP= chronic low back pain, CPSS= Chronic Pain Self-efficacy Scale, LBP= low back pain, FABQ= Fear Avoidance Beliefs Questionnaire, FABQ-PA= Physical Activity subscale of the FABQ, FABQ-W= Work subscale of the FABQ, mODI= modified Oswestry Disability Index, MVC= maximally voluntary contraction, ODI= Oswestry Disability Index, PASS= Pain Anxiety Stress Scale, PCL= Pain Cognition List, PCS= Pain Catastrophising Scale, PDI= Pain Disability Index, PHODA-SeV= Photograph Series of Daily Activities – Short electronic Version, PSEQ= Pain Self-Efficacy Questionnaire, QBPDS= Quebec Back Pain Disability Scale, RMDQ= Roland Morris Disability Questionnaire, TSK= Tampa Scale for Kinesiophobia, TSK-AA= Activity Avoidance subscale of the TSK, TSK-SF= Somatic Focus subscale of the TSK

Supplementary appendix D – Weighted means and pooled standard deviations of questionnaires assessing pain-related psychological factors

	All studies Weighted mean (pooled SD)	Studies included in meta-analyses Weighted mean (pooled SD)
Pain-related fear		
TSK-17 (17-68)	38.1 (7.4)	38.0 (6.7)
TSK-11 (11-44)	26.7 (6.9)	26.7 (6.9)
FABQ-PA (0-24)	16.9 (6.6)	16.9 (6.6)
FABQ-W (0-42)	24.6 (10.7)	24.6 (10.7)
Pain-catastrophising		
PCS (0-52)	22.4 (9.9)	20.2 (10.4)

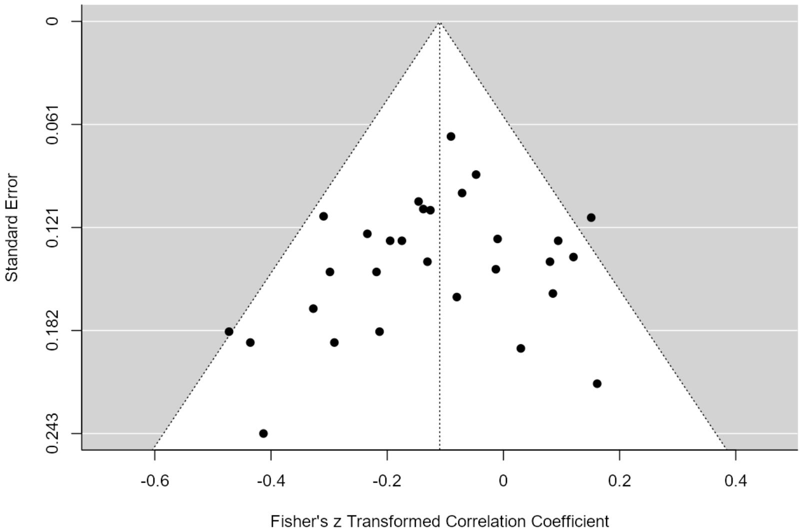
Weighted means and SDs were calculated when means and SDs for a particular questionnaire were available for ≥2 studies included in the review. For calculating the weighted means and pooled SDs, the number of participants per study was taken into account.

Supplementary appendix E - Funnel plots for meta-analyses including ≥ 10 studies

1. Pain-related fear

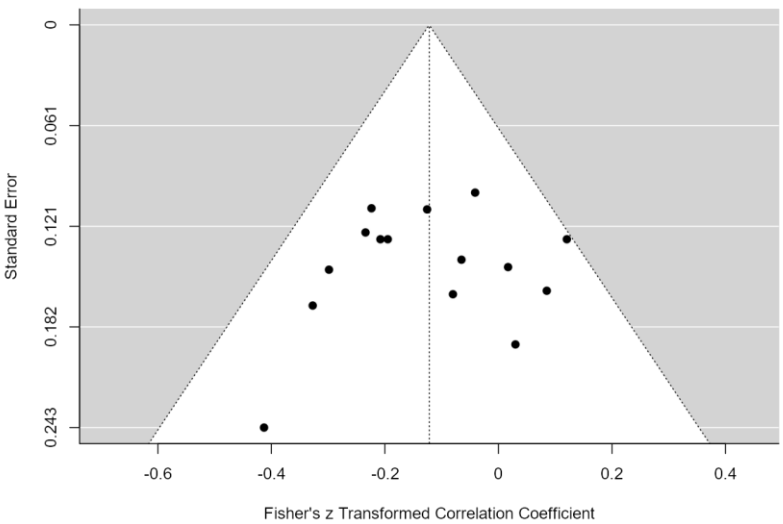
1.1 All questionnaires combined

1.1.1 All studies combined



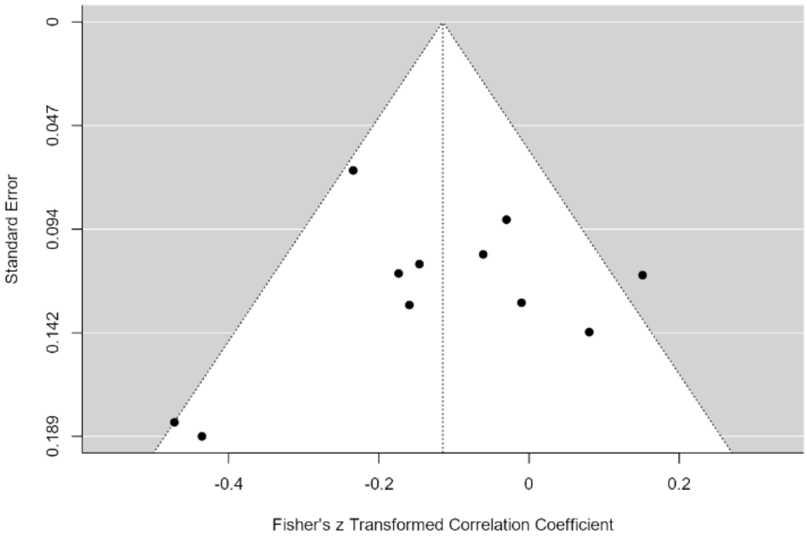
Egger's regression value= -1.27 (p= 0.20)

1.1.2 Trunk muscle strength



Egger's regression value= -0.41 (p= 0.68)

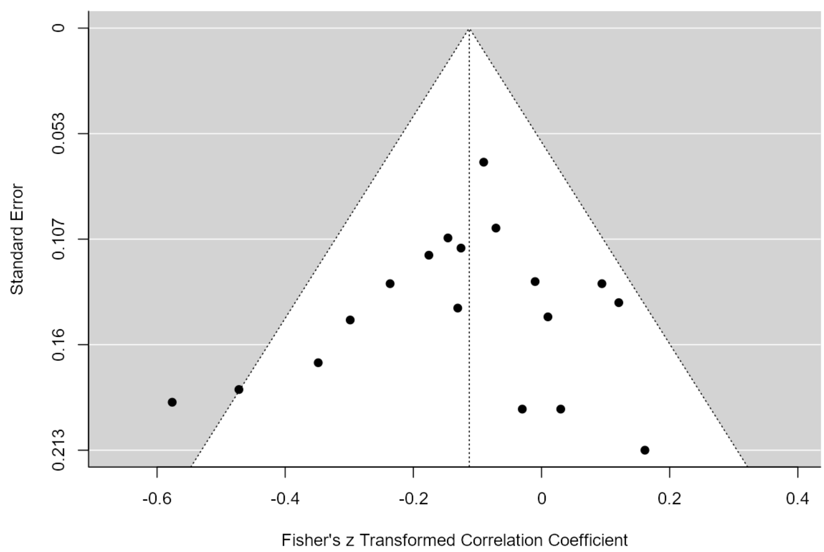
1.1.3 Lifting capacity



Egger's regression value= -0.98 (p= 0.32)

1.2 Tampa Scale for Kinesiophobia total score

1.2.1 <u>All studies combined</u>



Egger's regression value= -0.76 (p= 0.45)

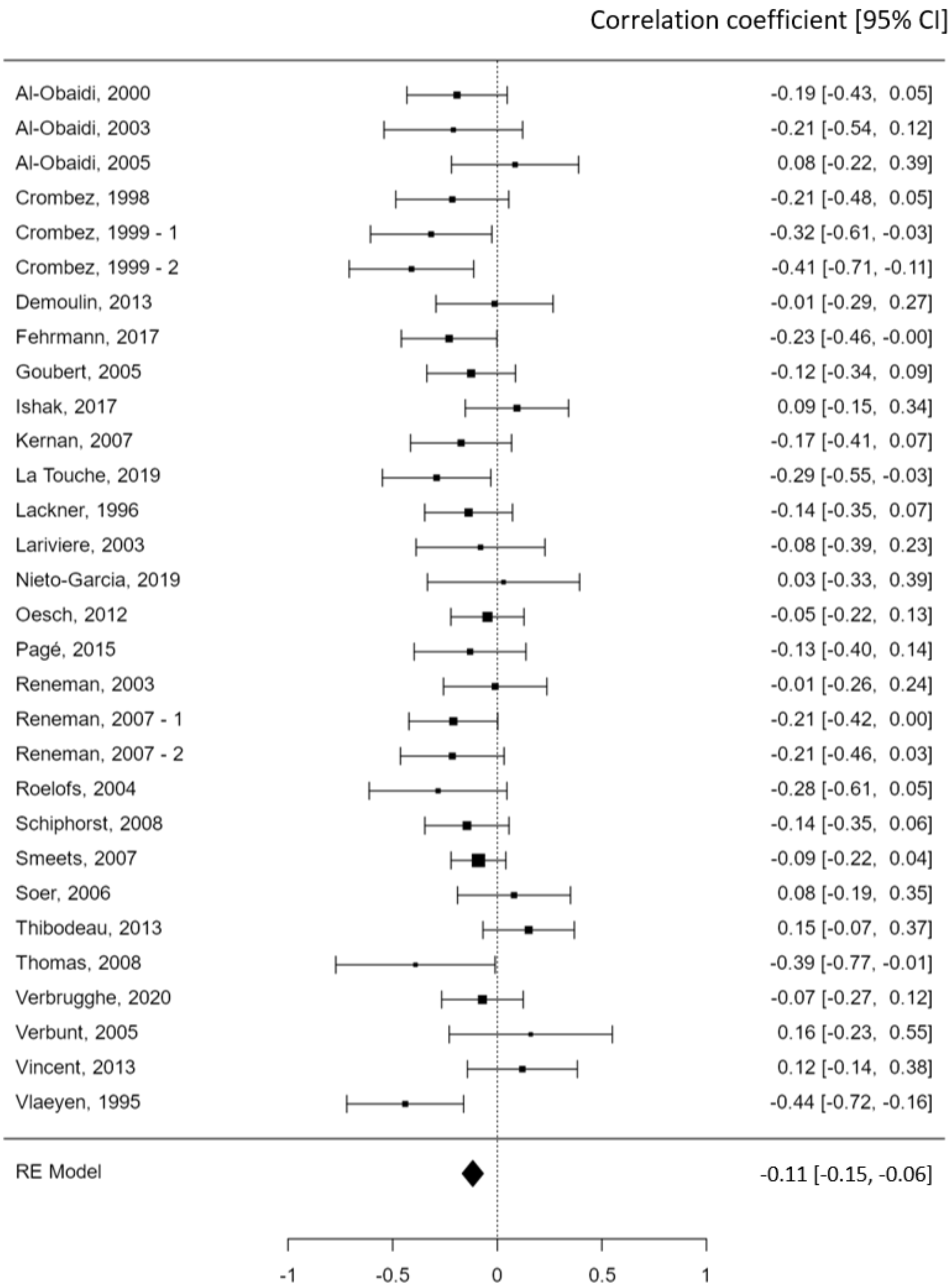
Supplementary appendix F - Forest plots for general meta-analyses

The pooled correlation coefficient was calculated by first transforming the correlation coefficients of the individual studies using a Fisher's z transformation. Meta-analyses were performed using the z-scores, after which an inverse Fisher's z transformation was used to obtain the pooled correlation coefficient and 95% confidence interval. This is the pooled correlation coefficient (95% CI) that is shown in each forest plot. For enhancing the clinical interpretation, the correlation coefficients with the 95% confidence interval (instead of the z-scores) are shown for each individual study in the forest plots. Two separate studies (each in a different participant group) were reported in Crombez *et al* (1999) and Reneman *et al* (2007). In the forest plots, we refer to the respective first studies as Crombez, 1999 – 1 and Reneman, 2007 - 1, and to the second studies as Crombez, 1999 – 2 and Reneman, 2007 - 2.

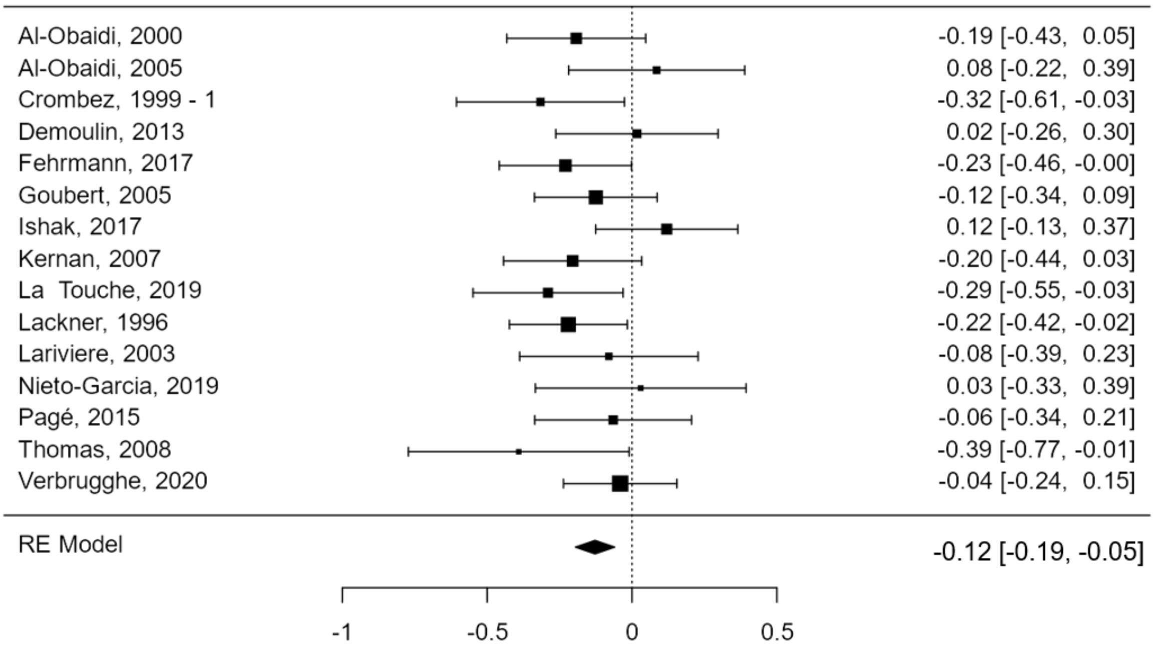
1. Pain-related fear

1.1 All questionnaires combined

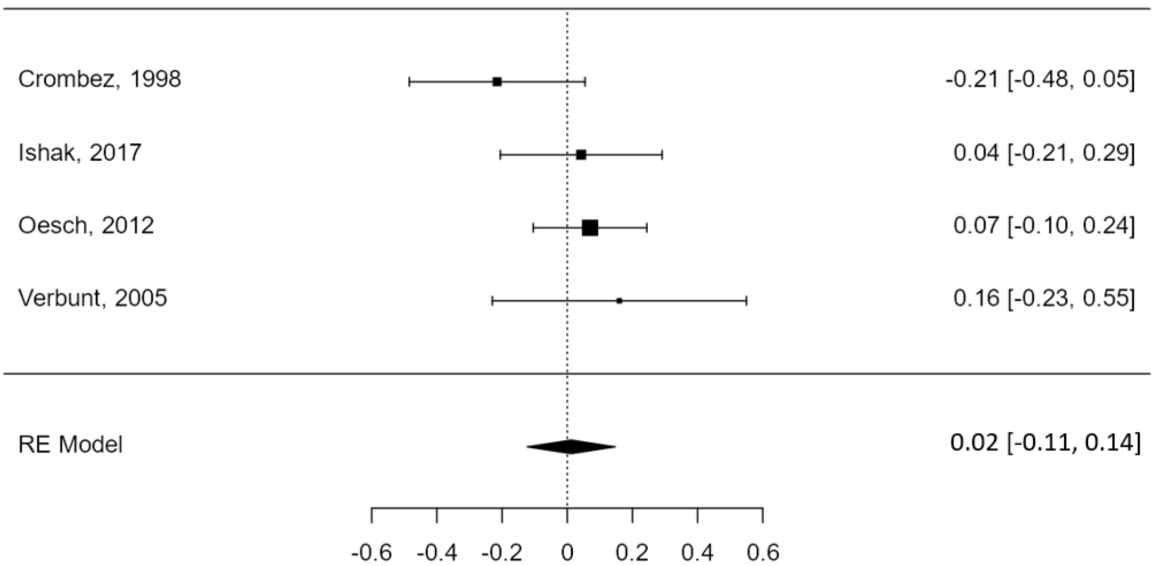
1.1.1 *<u>All studies combined</u>*



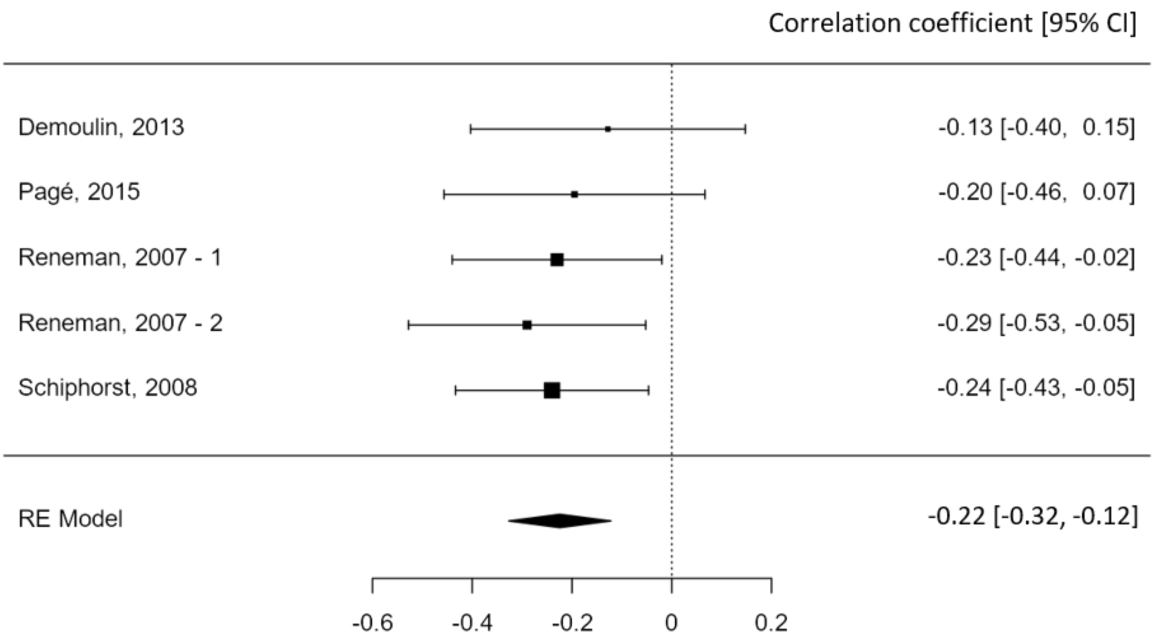
1.1.2 *Trunk muscle strength*



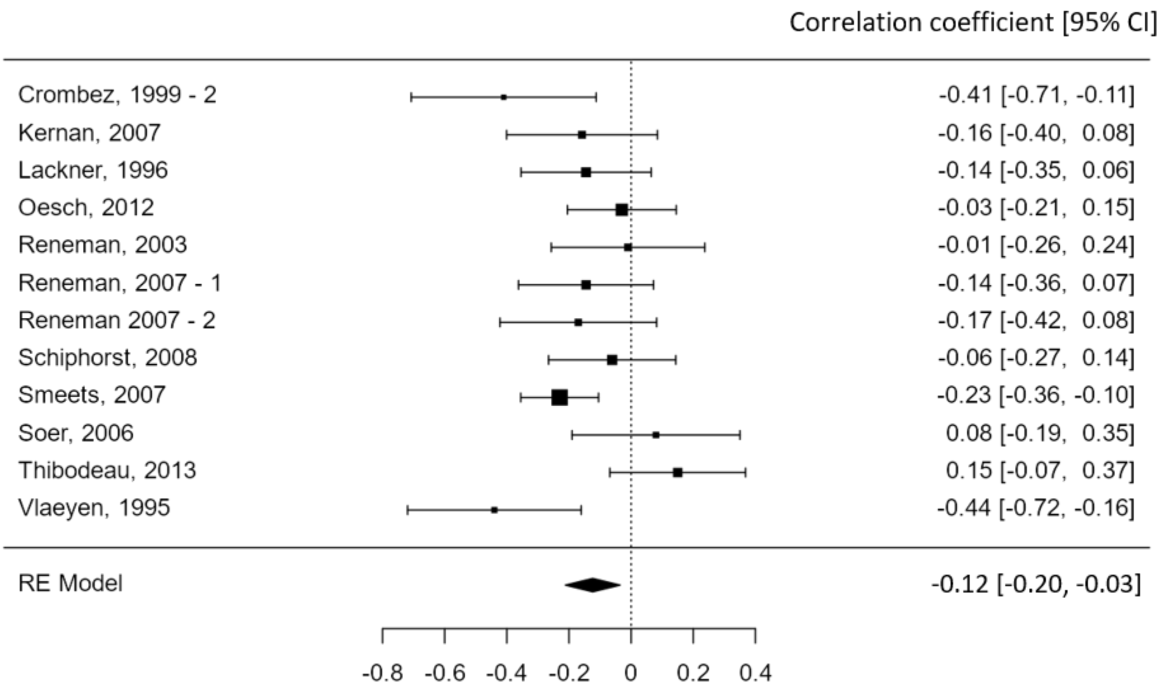
1.1.3 *Extremity muscle strength*



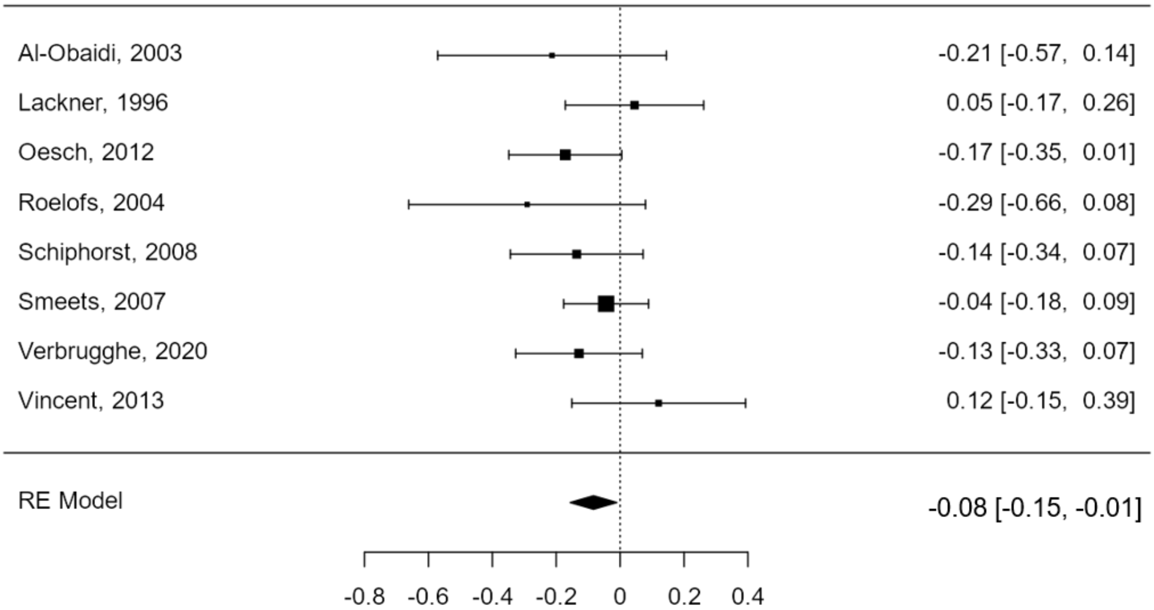
1.1.4 Trunk muscle endurance



1.1.5 Lifting capacity

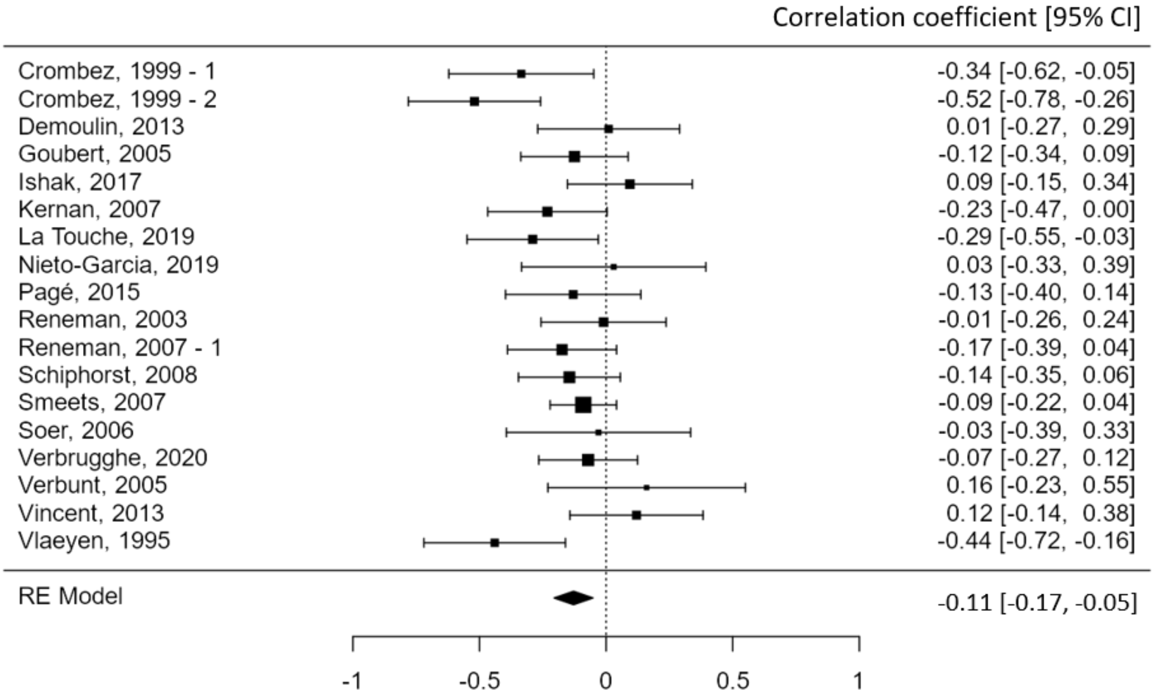


1.1.6 Functional mobility

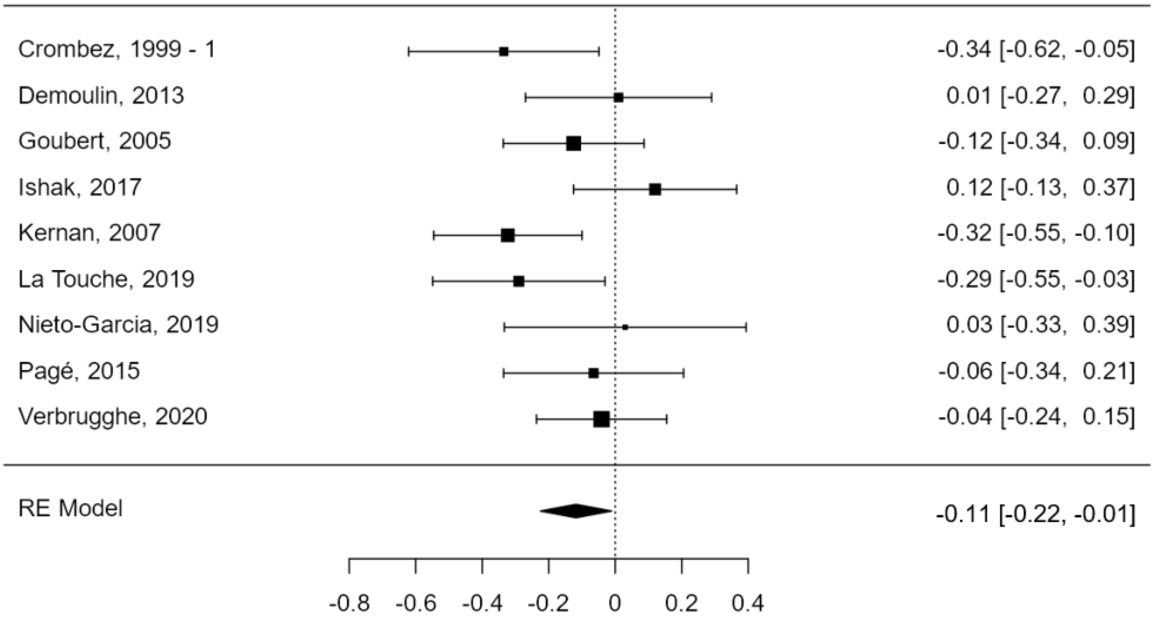


1.2 Tampa Scale for Kinesiophobia (total score)

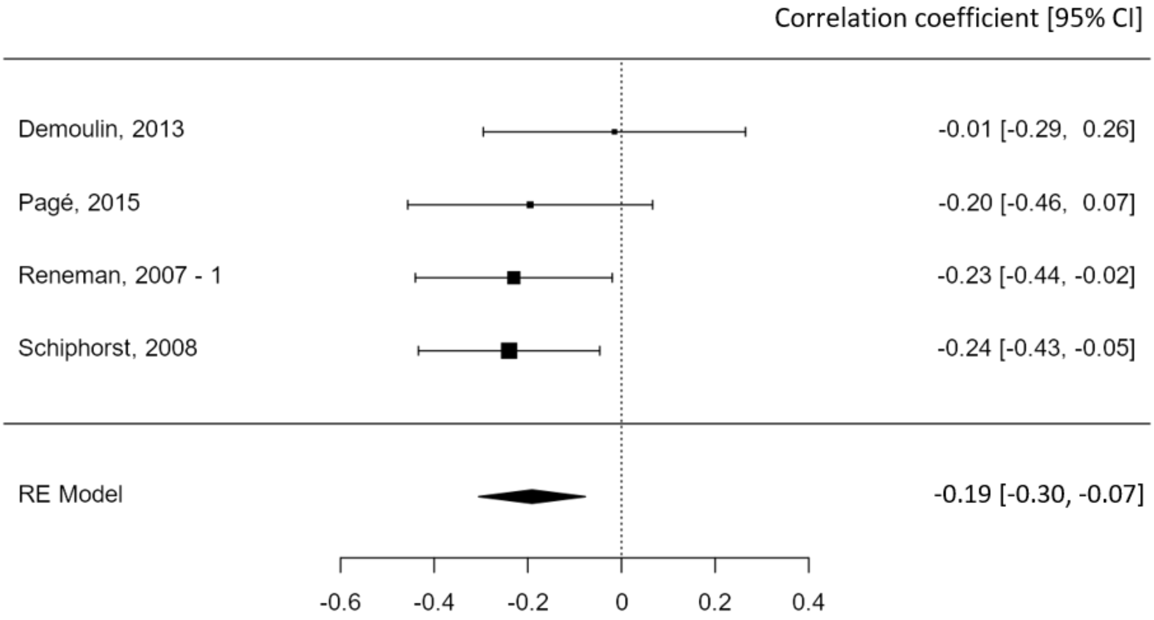
1.2.1 All studies combined



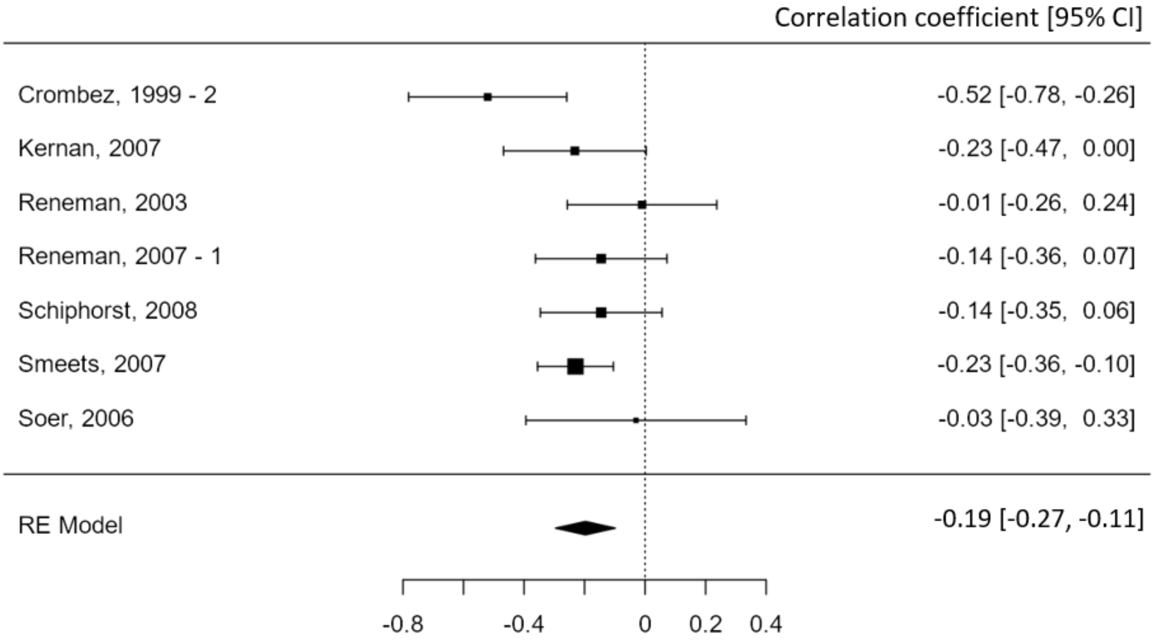
1.2.2 Trunk muscle strength



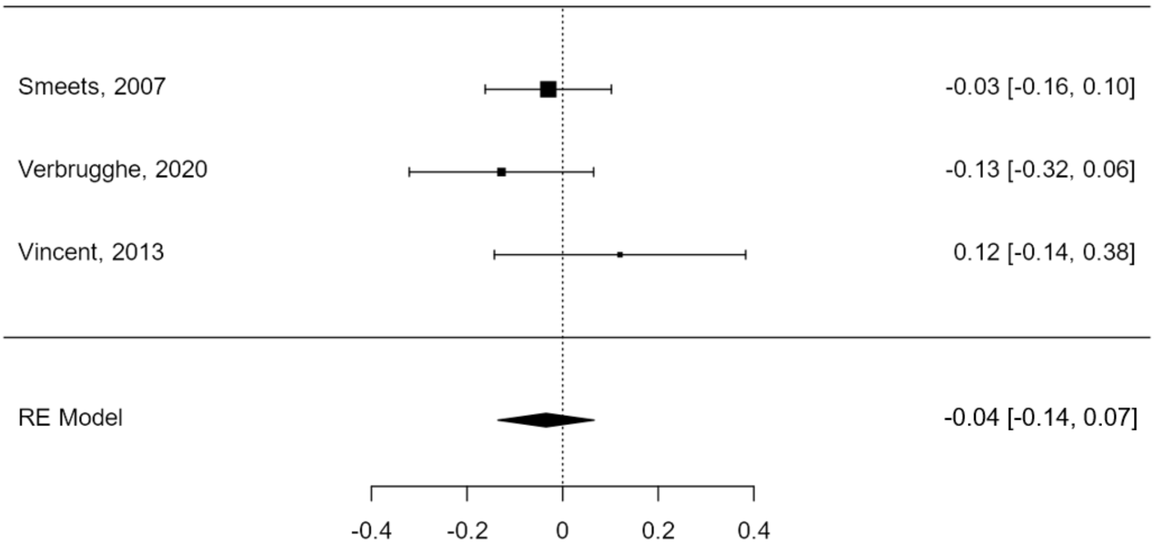
1.2.3 Trunk muscle endurance



1.2.4 Lifting capacity

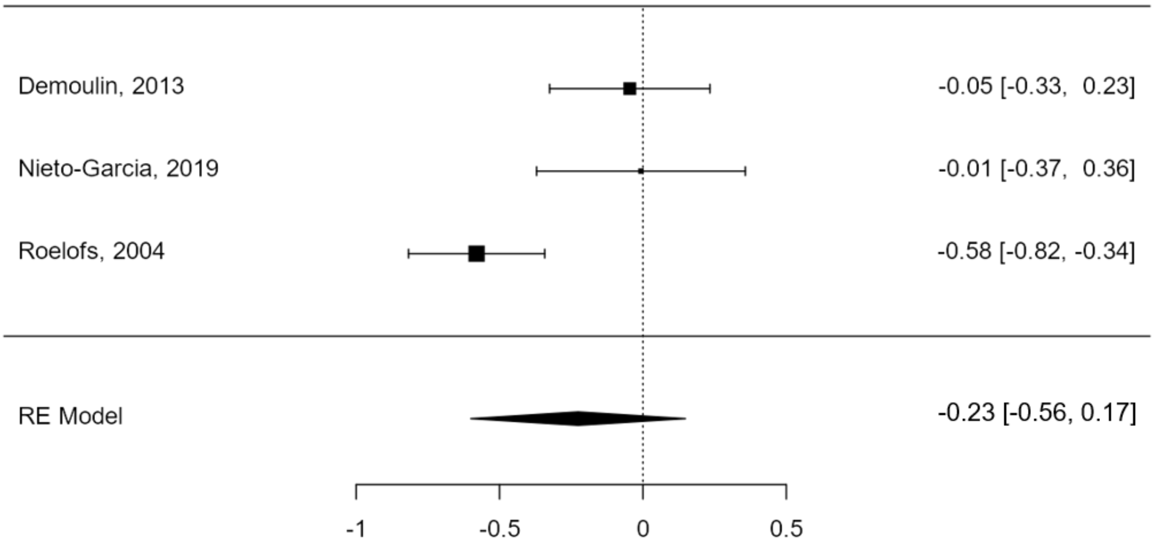


1.2.5 Functional mobility



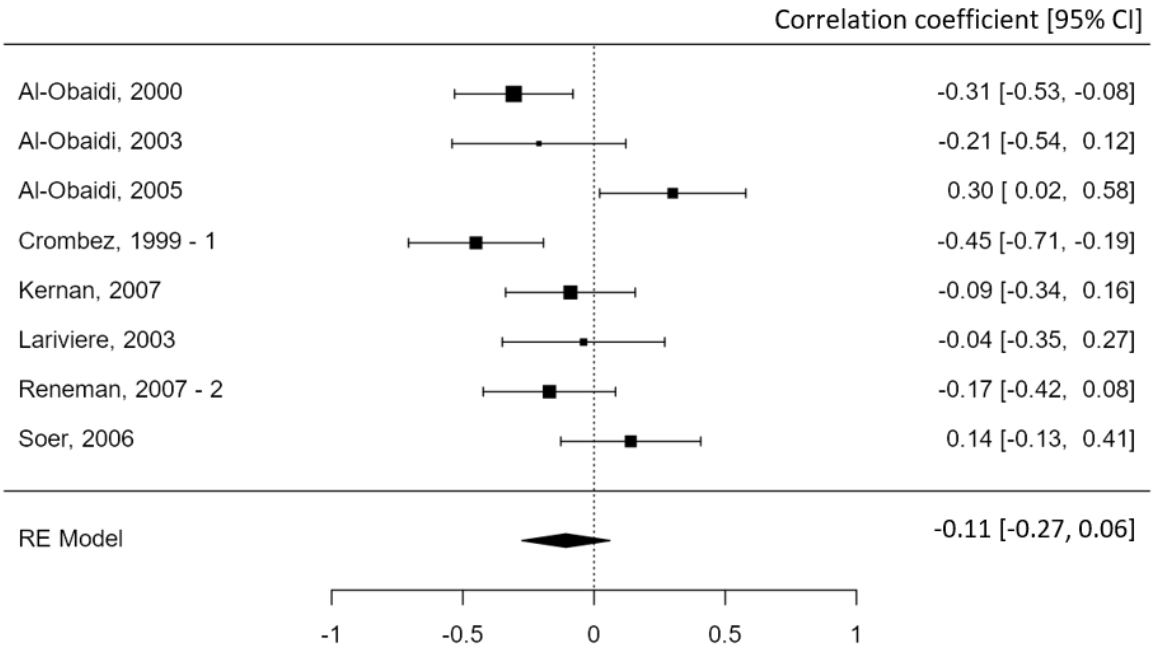
1.3 Tampa Scale for Kinesiophobia – Activity Avoidance subscale

1.3.1 All studies combined

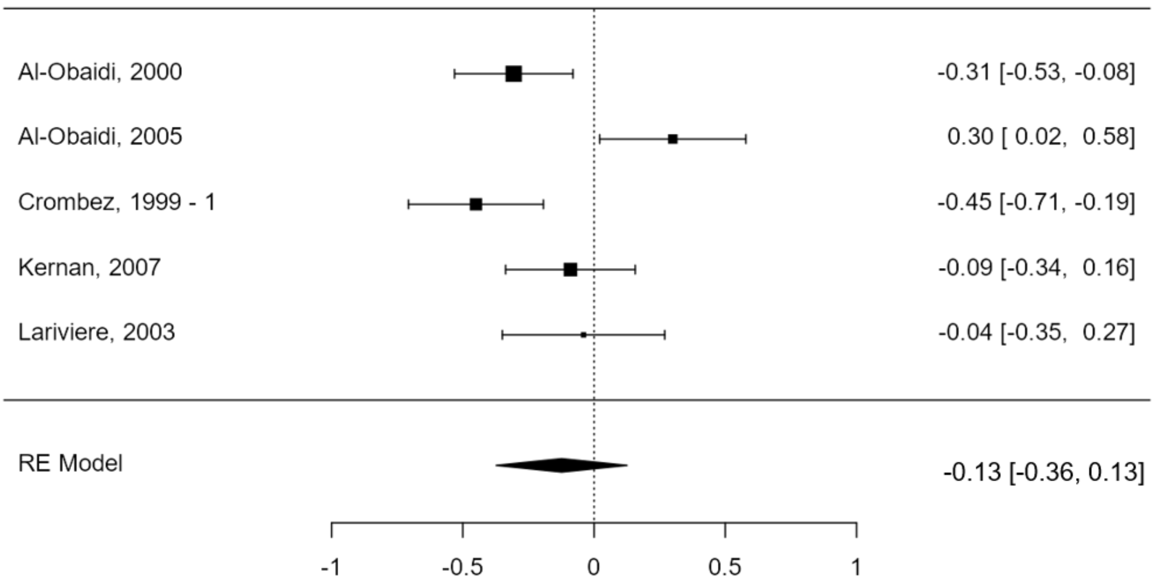


1.4 Fear Avoidance Beliefs Questionnaire – Physical Activity subscale

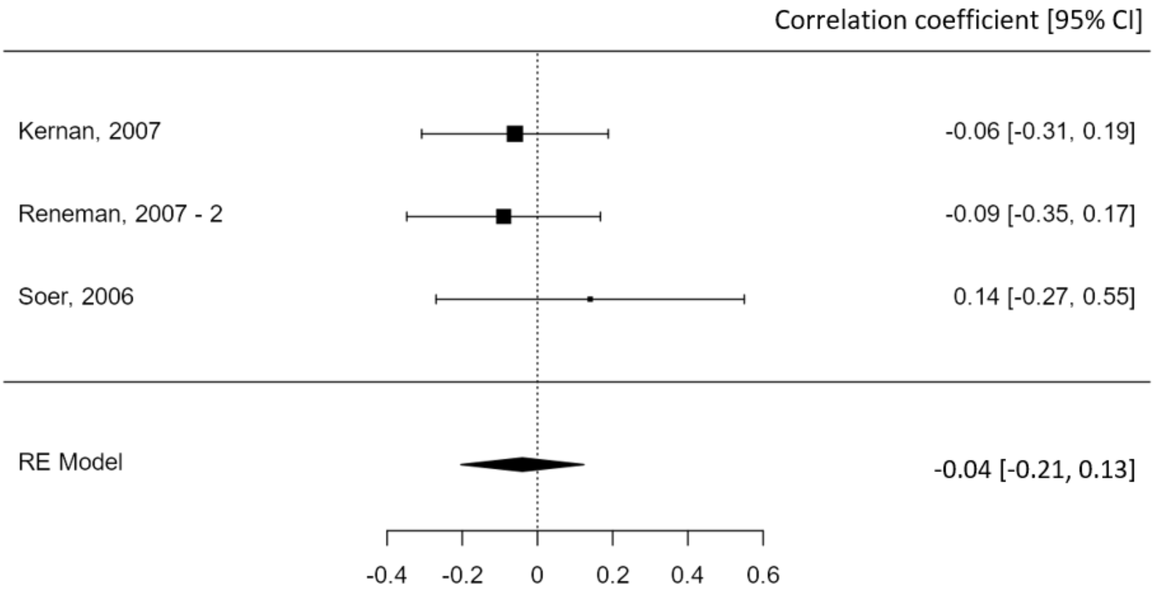
1.4.1 All studies combined



1.4.2 Trunk muscle strength

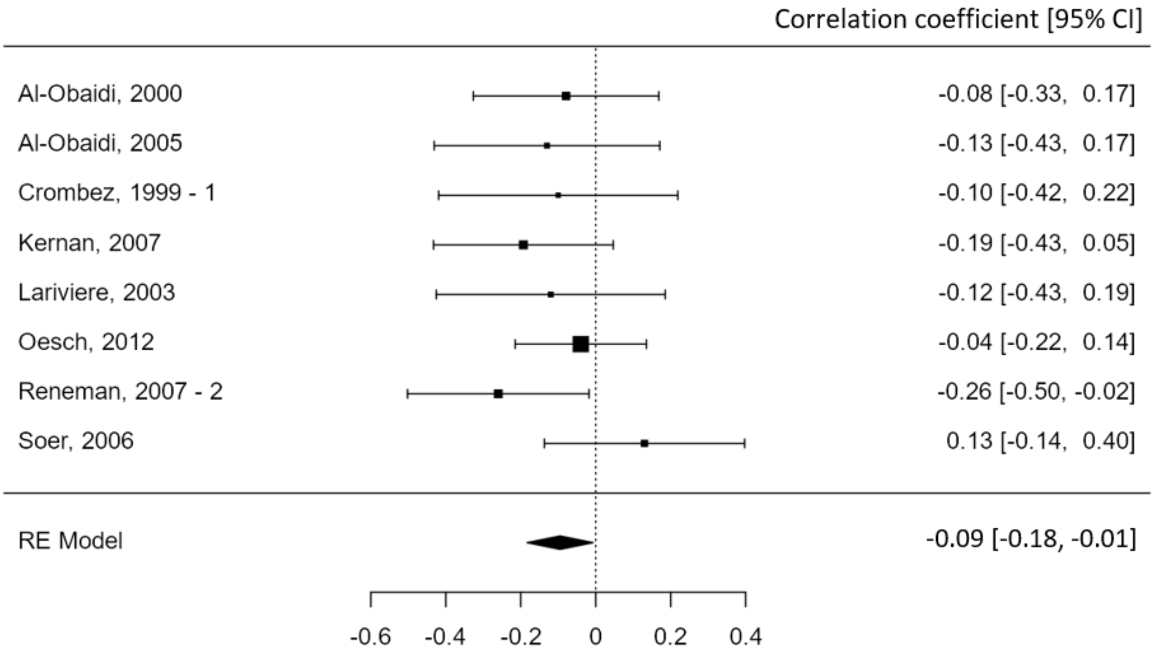


1.4.3 Lifting capacity

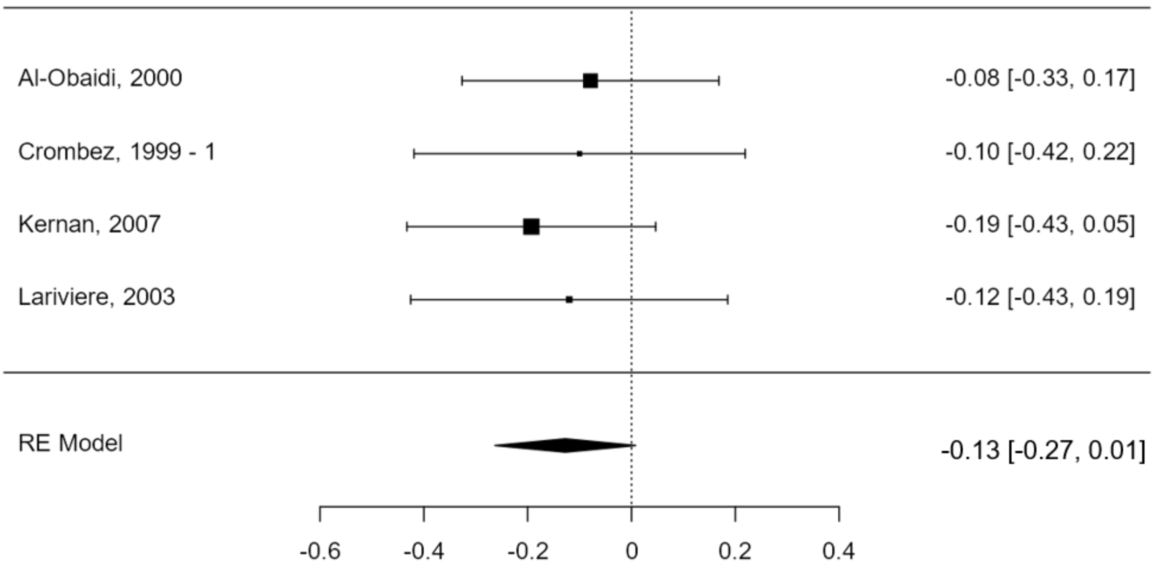


1.5 Fear Avoidance Beliefs Questionnaire – Work subscale

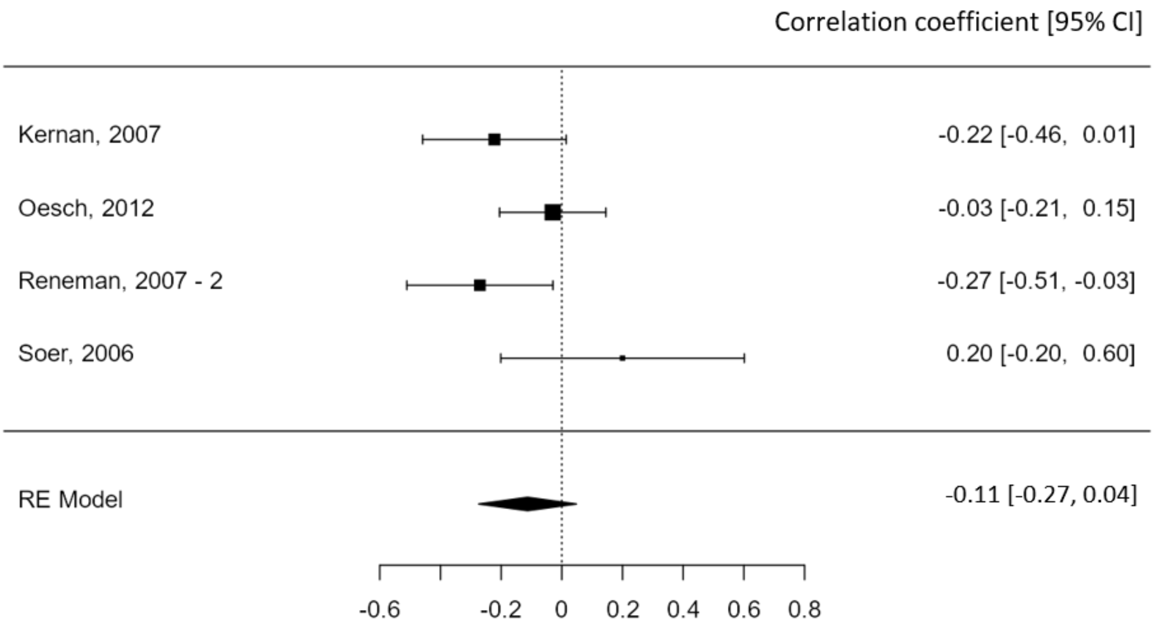
1.5.1 All studies combined



1.5.2 Trunk muscle strength

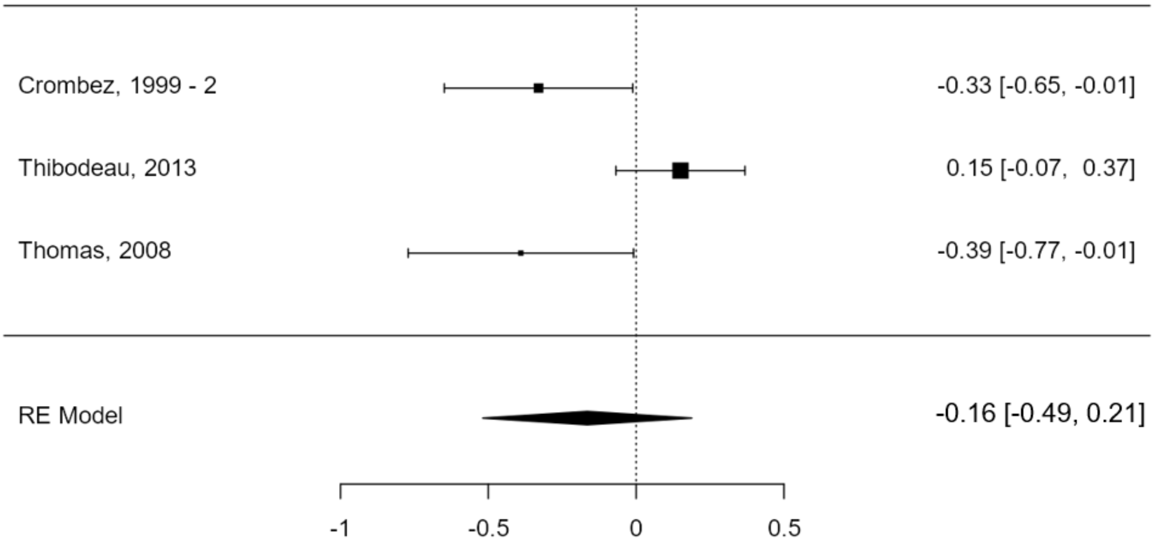


1.5.3 <u>Lifting capacity</u>



1.6 Pain Anxiety Symptoms Scale

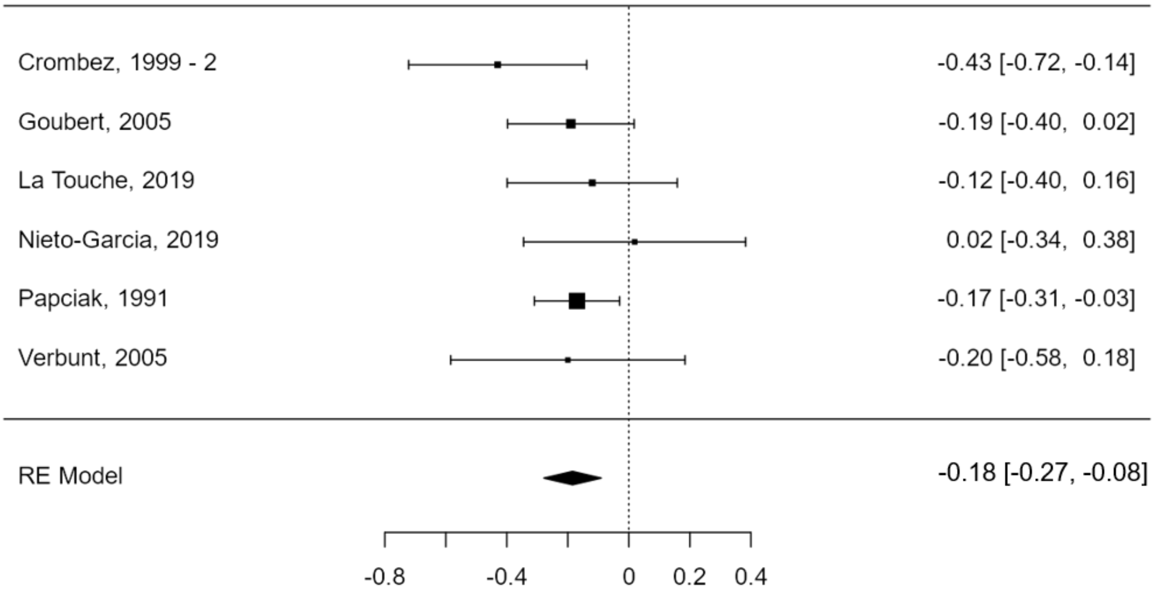
1.6.1 All studies combined



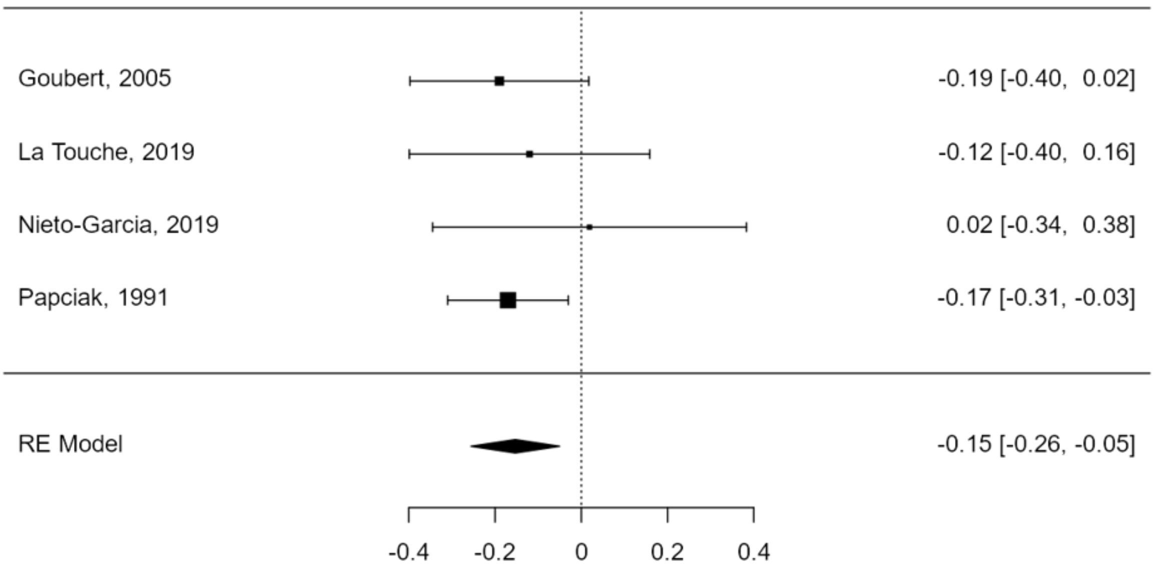
2. Pain catastrophising

2.1 All questionnaires combined

2.1.1 All studies combined

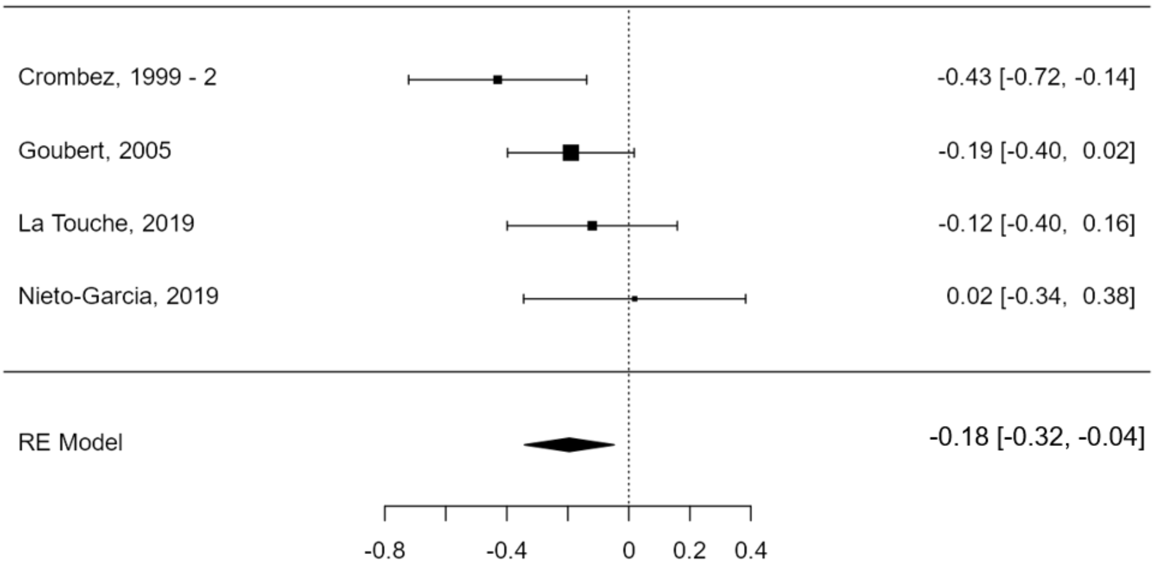


2.1.2 Trunk muscle strength

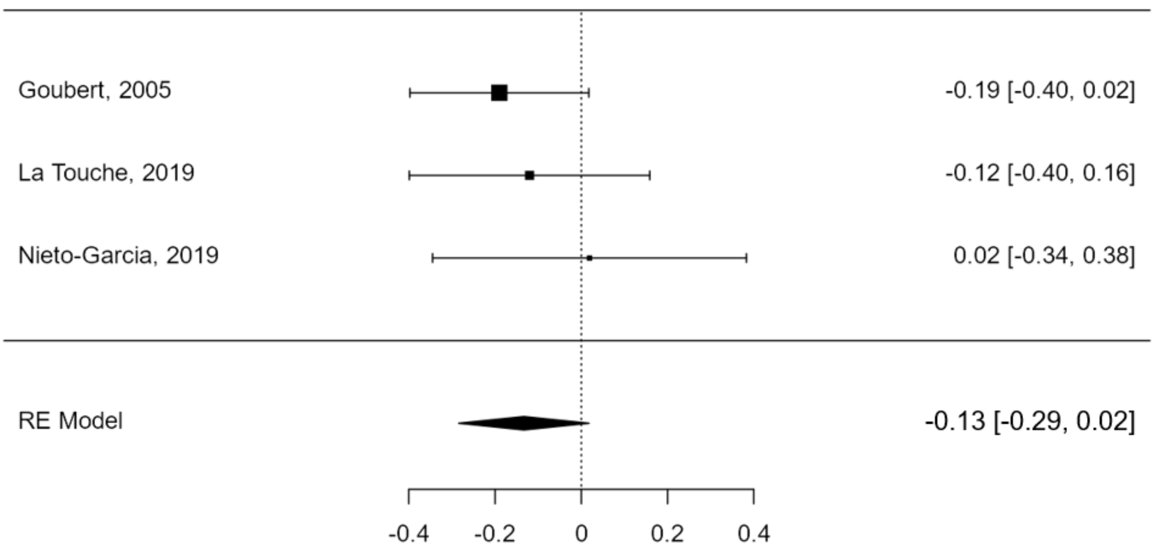


2.2 Pain Catastrophising Scale

2.2.1 All studies combined



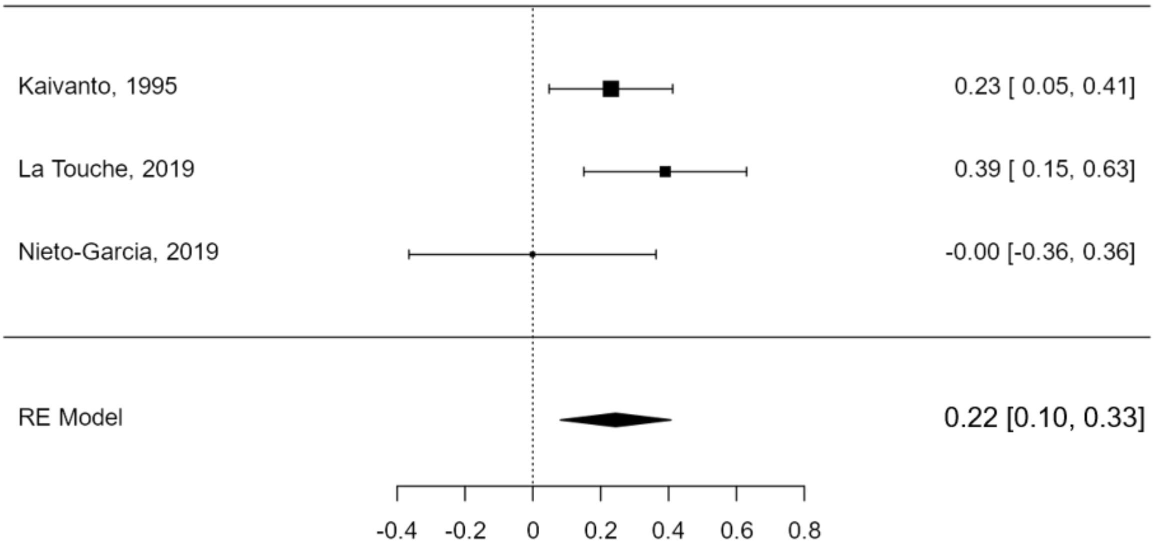
2.2.2 Trunk muscle strength



3. Pain self-efficacy

3.1 All questionnaires combined

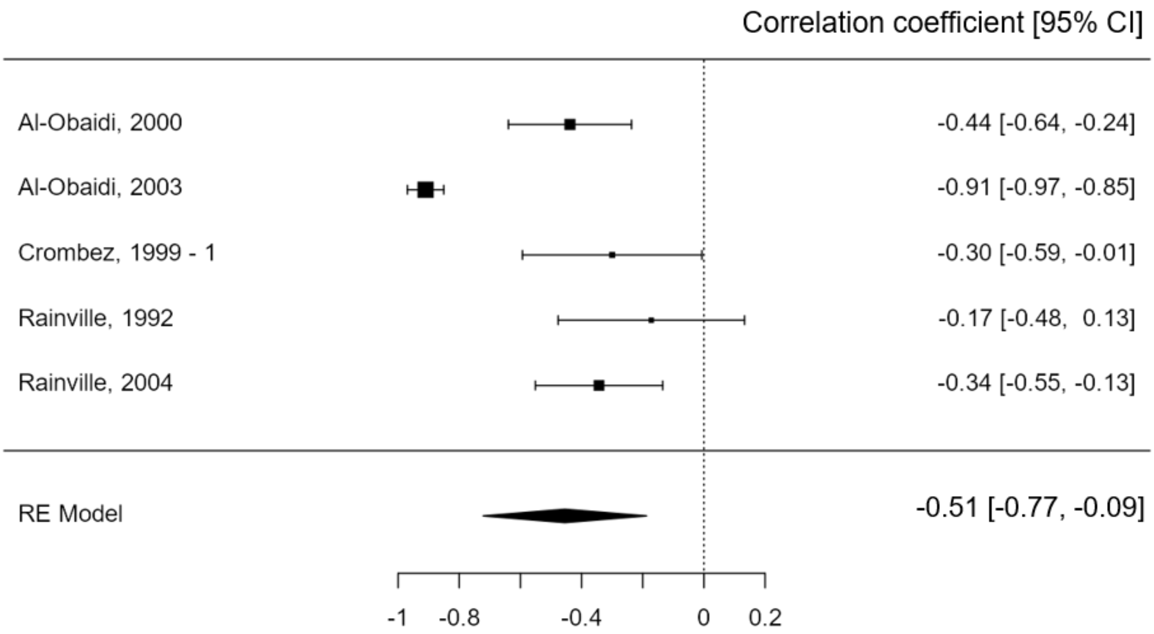
3.1.1 *All studies combined*



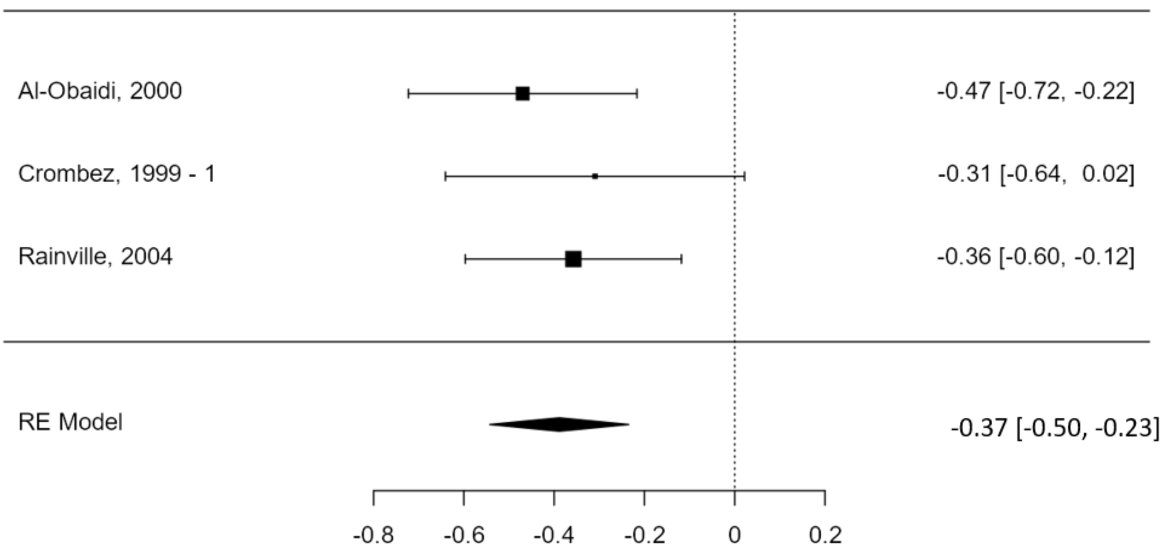
4. Anticipated pain

4.1 All questionnaires combined

4.1.1 <u>All studies combined</u>



4.1.2 <u>Trunk muscle strength</u>



Supplementary appendix G - Forest plots for sensitivity analyses including studies controlling for personal factors

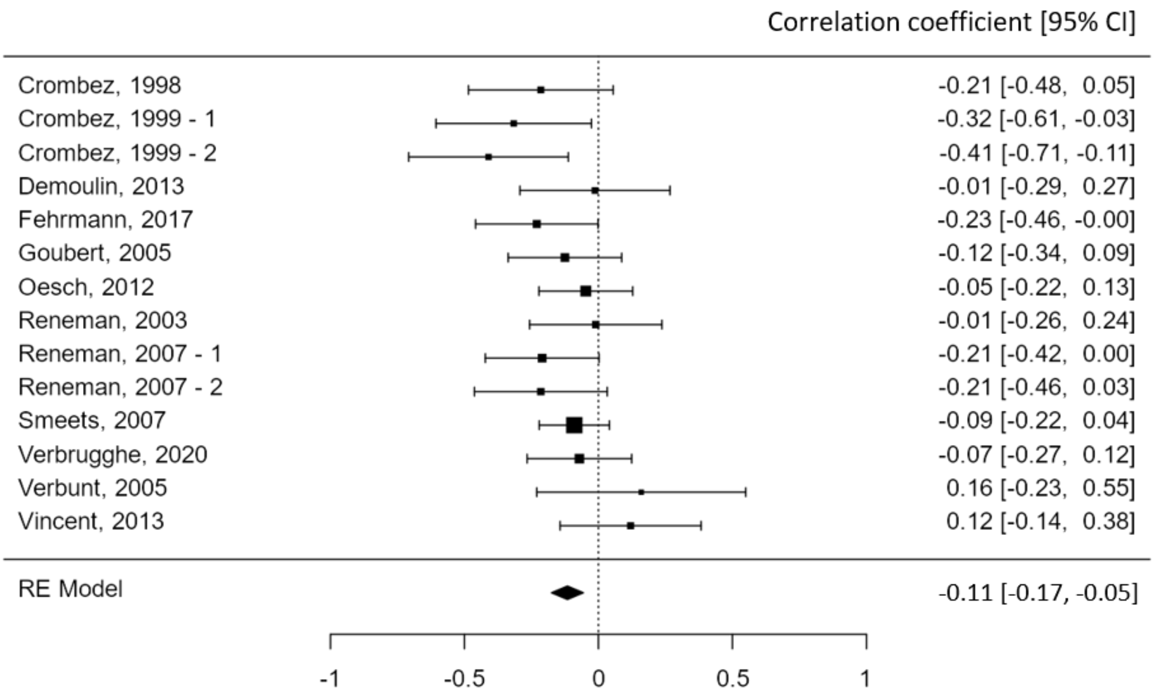
The pooled correlation coefficient was calculated by first transforming the correlation coefficients of the individual studies using a Fisher's z transformation. Meta-analyses were performed using the z-scores, after which an inverse Fisher's z transformation was used to obtain the pooled correlation coefficient and 95% confidence interval. This is the pooled correlation coefficient (95% CI) that is shown in each forest plot. For enhancing the clinical interpretation, the correlation coefficients with the 95% confidence interval (instead of the z-scores) are shown for each individual study in the forest plots. Two separate studies (each in a different participant group) were reported in Crombez *et al* (1999) and Reneman *et al* (2007). In the forest plots, we refer to the respective first studies as Crombez, 1999 – 1 and Reneman, 2007 - 1, and to the second studies as Crombez, 1999 – 2 and Reneman, 2007 - 2.

Studies were included in these sensitivity analyses when they had a low risk of bias on the categories 'study confounding' and 'statistical analysis and reporting'. For a low risk of bias on study confounding, studies had to control for at least two of the following personal factors: sex, age or bodyweight (or bodyweight-related measures, such as body-mass index).

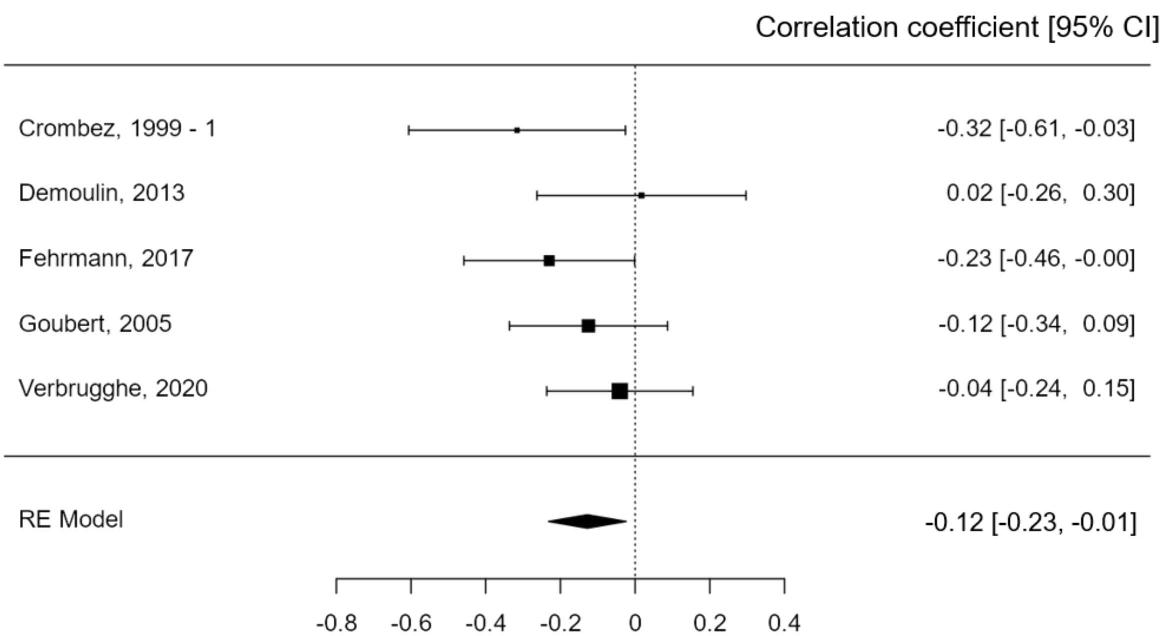
1. Pain-related fear

1.1 All questionnaires combined

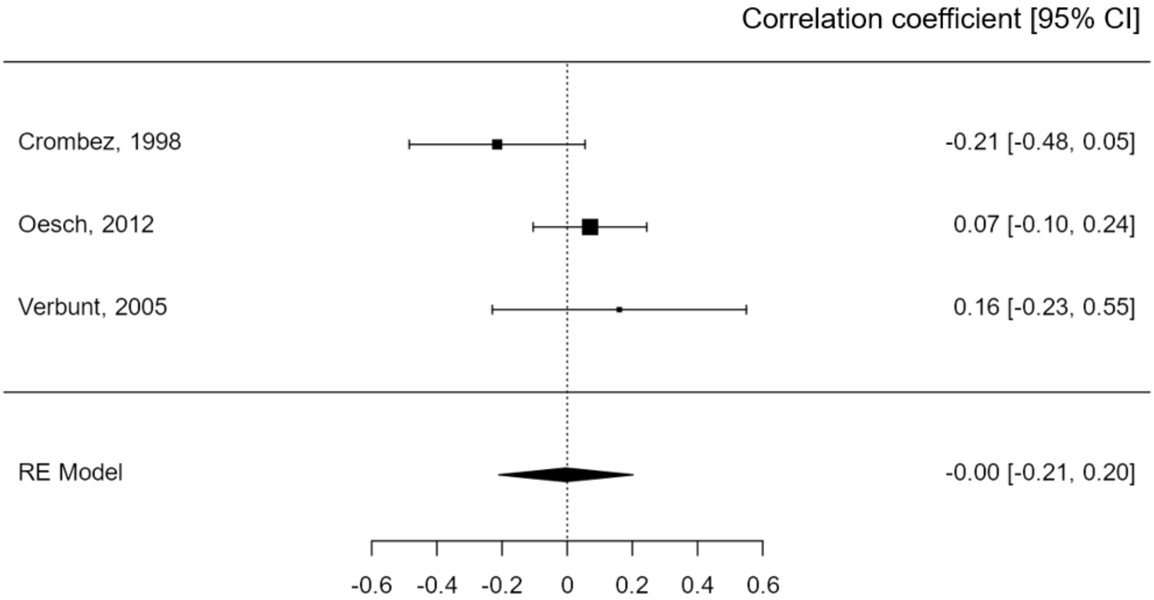
1.1.1 All studies combined



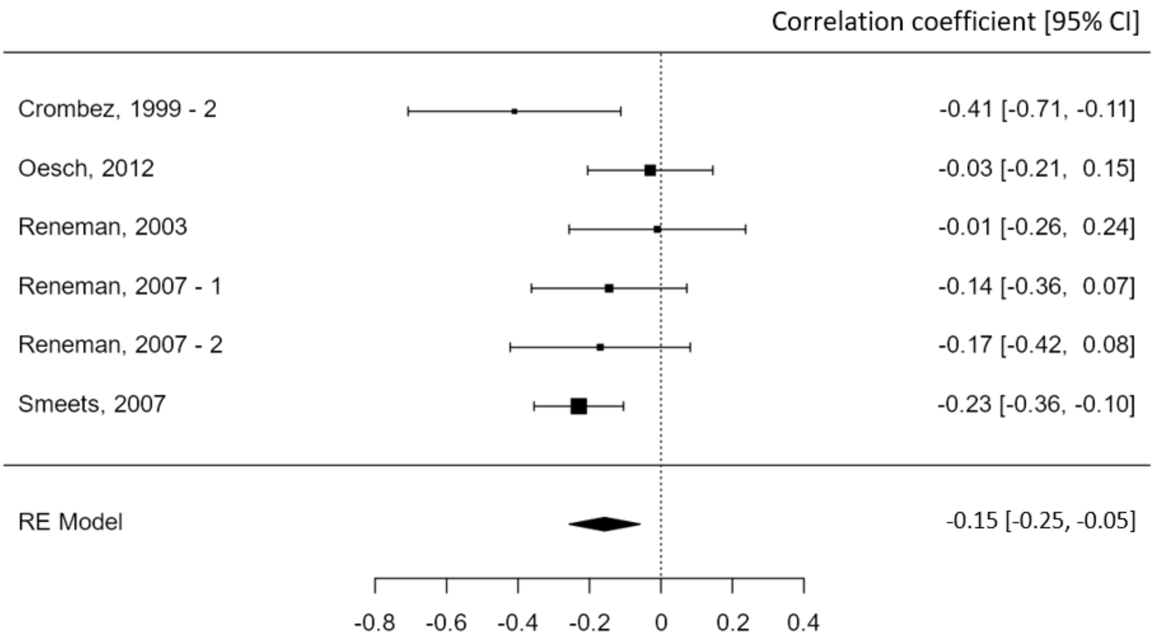
1.1.2 Trunk muscle strength



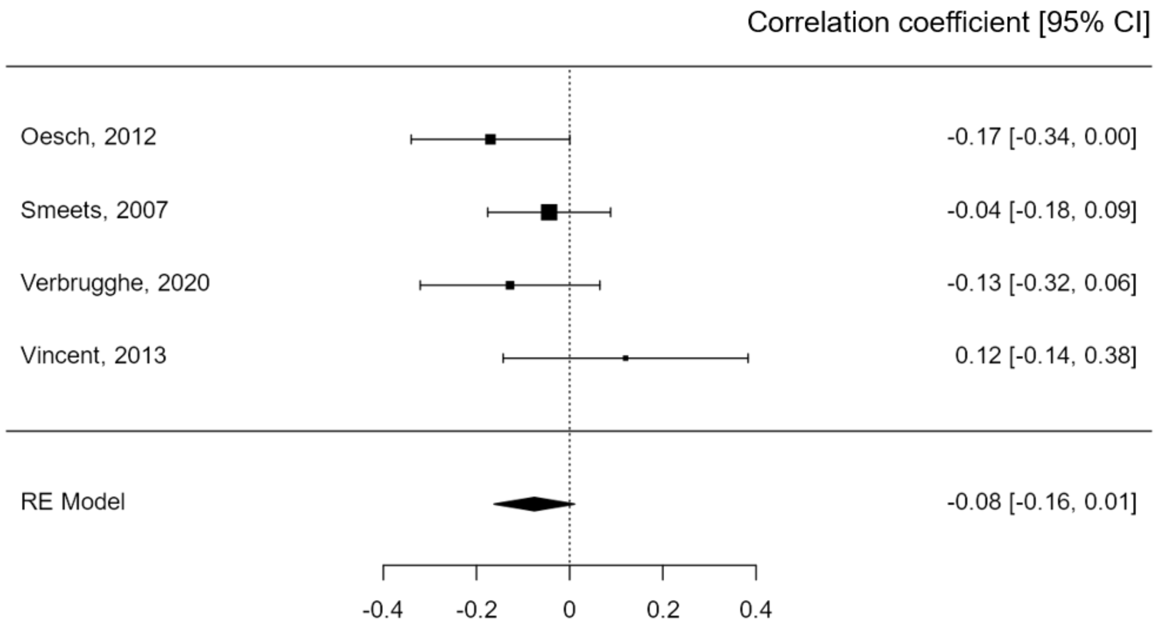
1.1.3 <u>Extremity muscle strength</u>



1.1.4 <u>Lifting capacity</u>

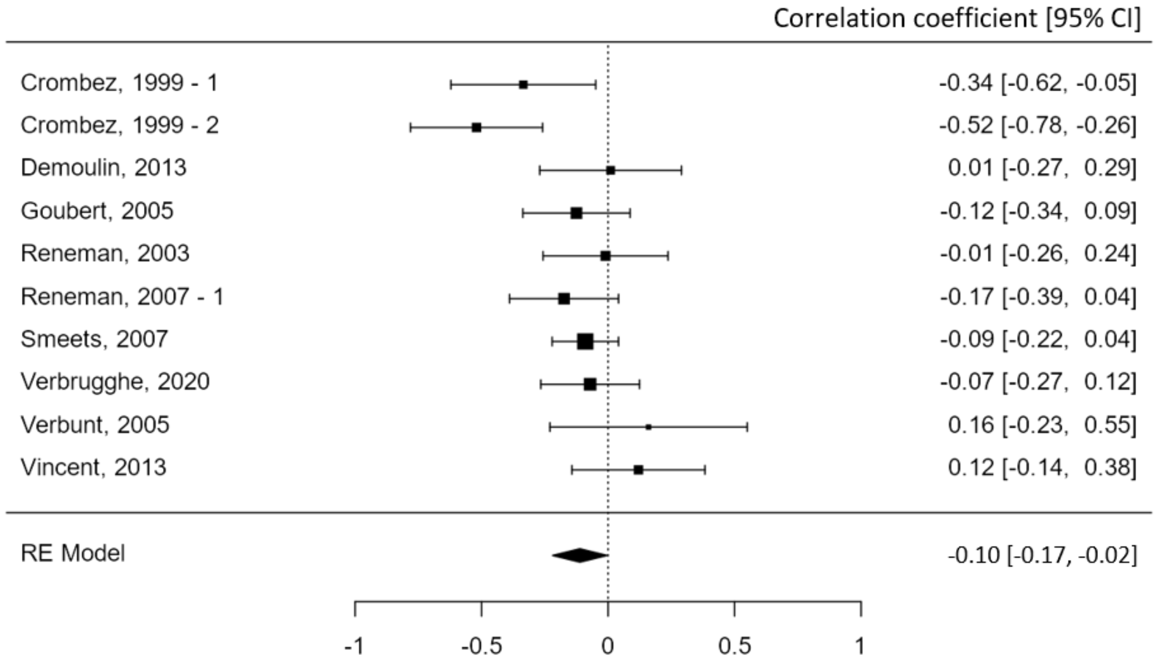


1.1.5 Functional mobility

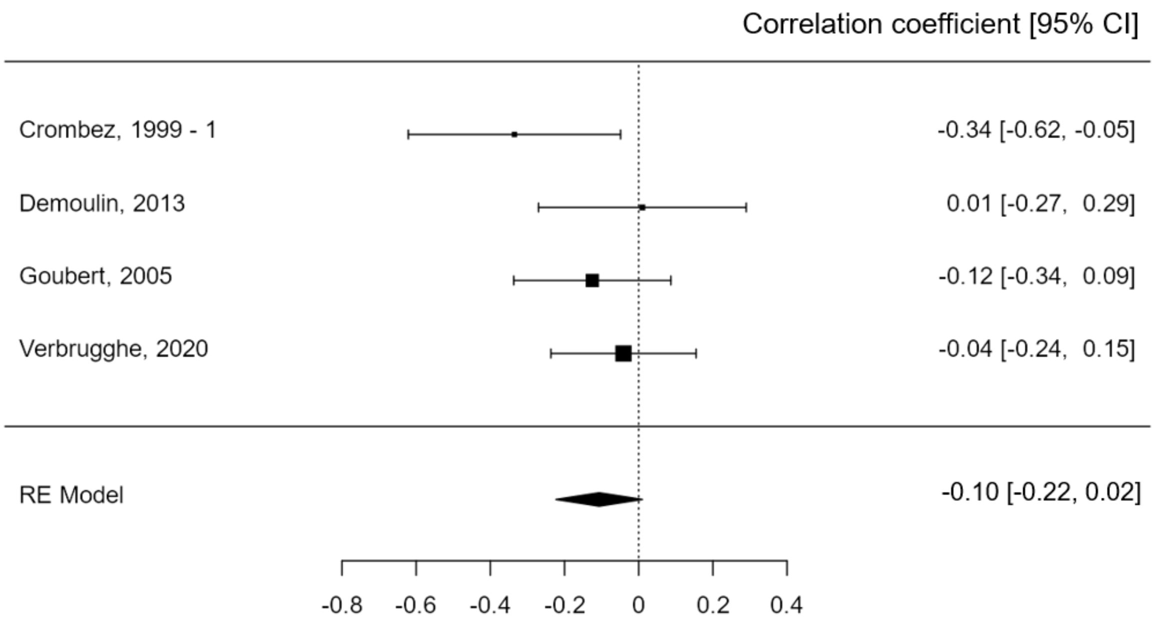


1.2 Tampa Scale for Kinesiophobia – Total score

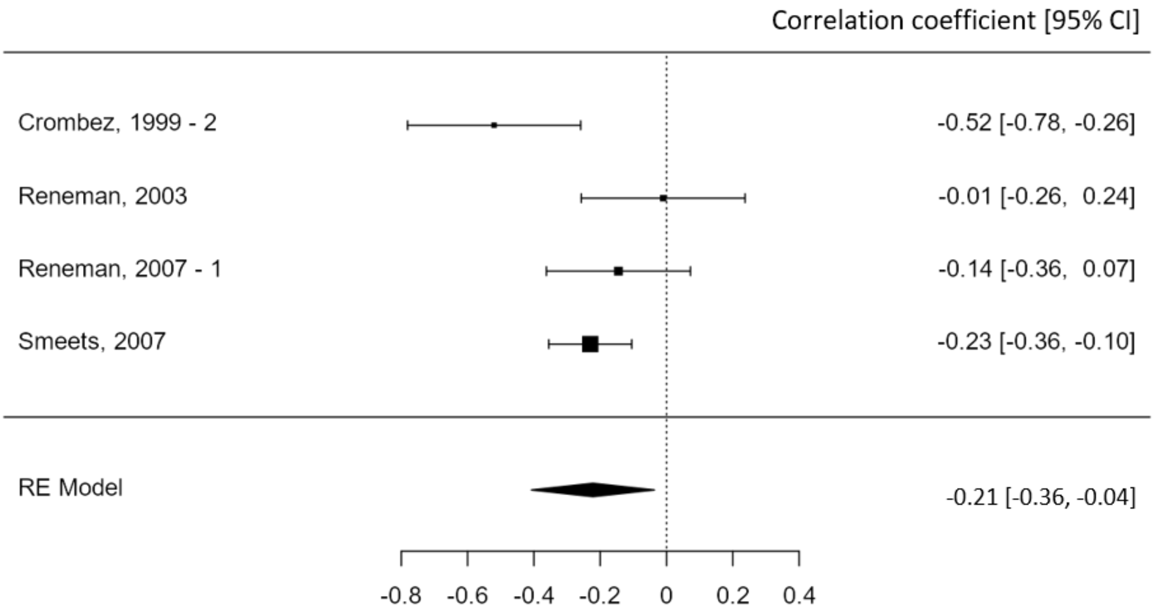
1.2.1 All studies combined



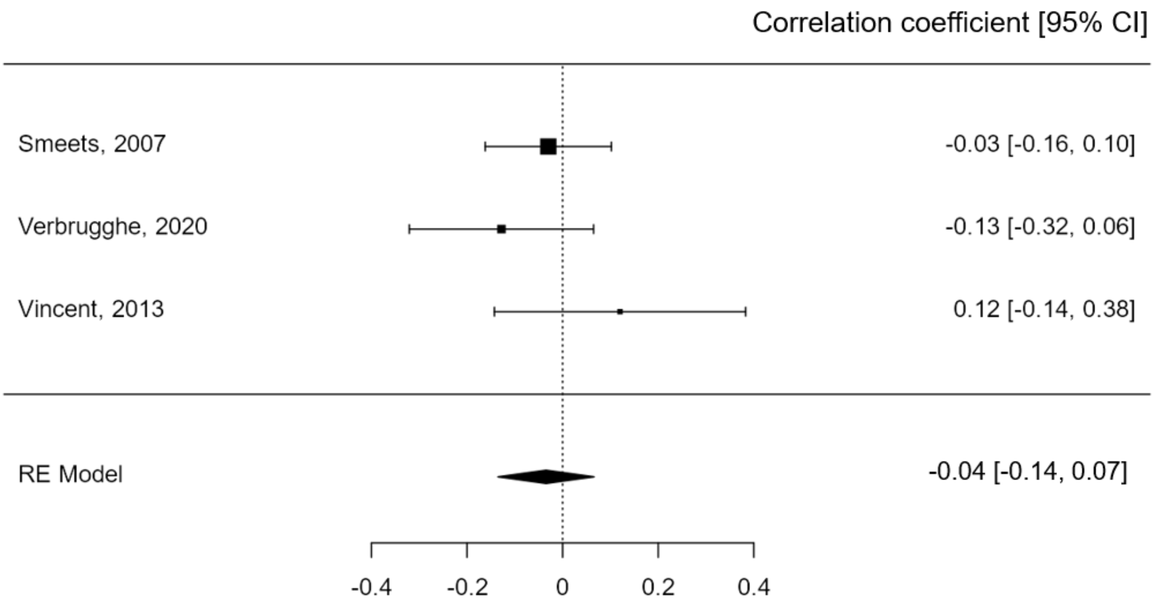
1.2.2 Trunk muscle strength



1.2.3 Lifting capacity

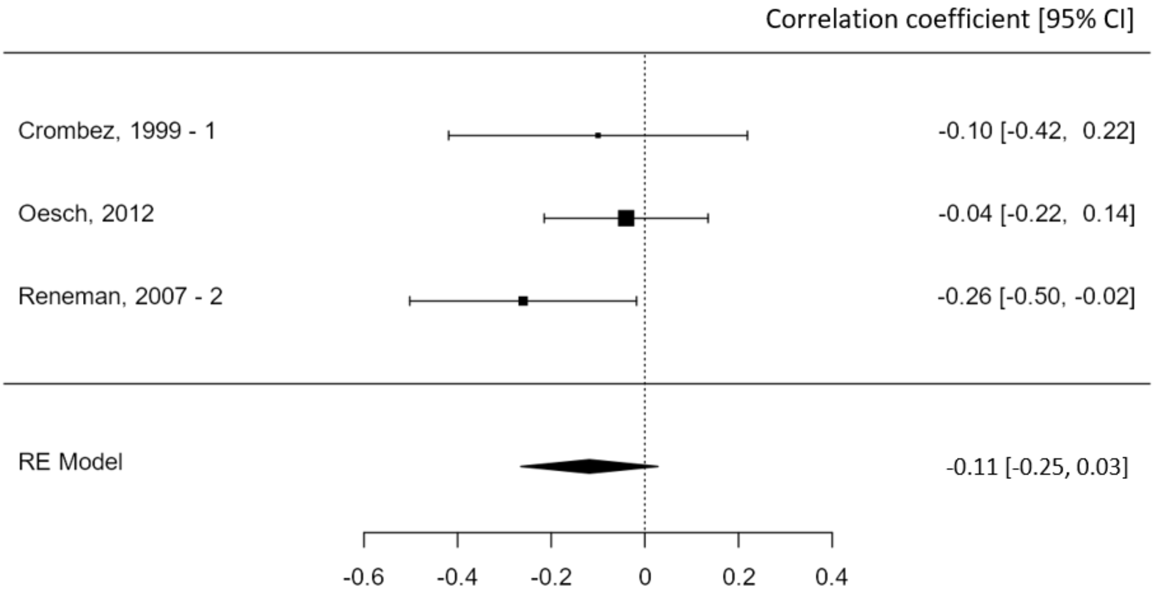


1.2.4 functional mobility



1.3 Fear Avoidance Beliefs Questionnaire – Work subscale

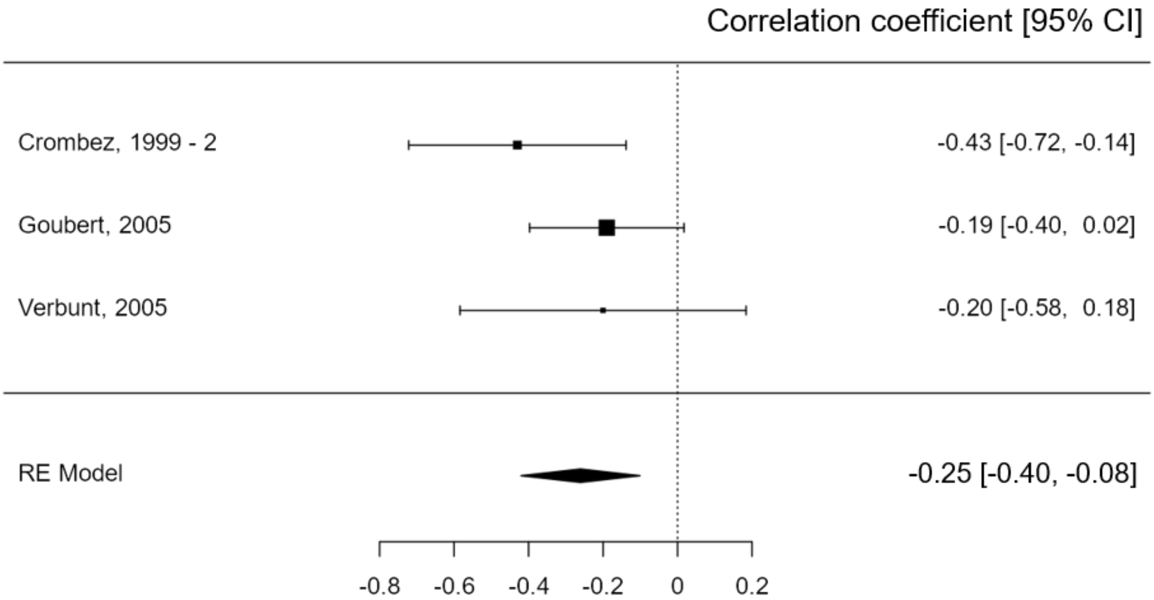
1.3.1 *All studies combined*



2. Pain catastrophising

2.1 All questionnaires combined

2.1.1 *All studies combined*



Supplementary appendix H - Forest plots for sensitivity analyses including studies controlling for personal factors and pain intensity

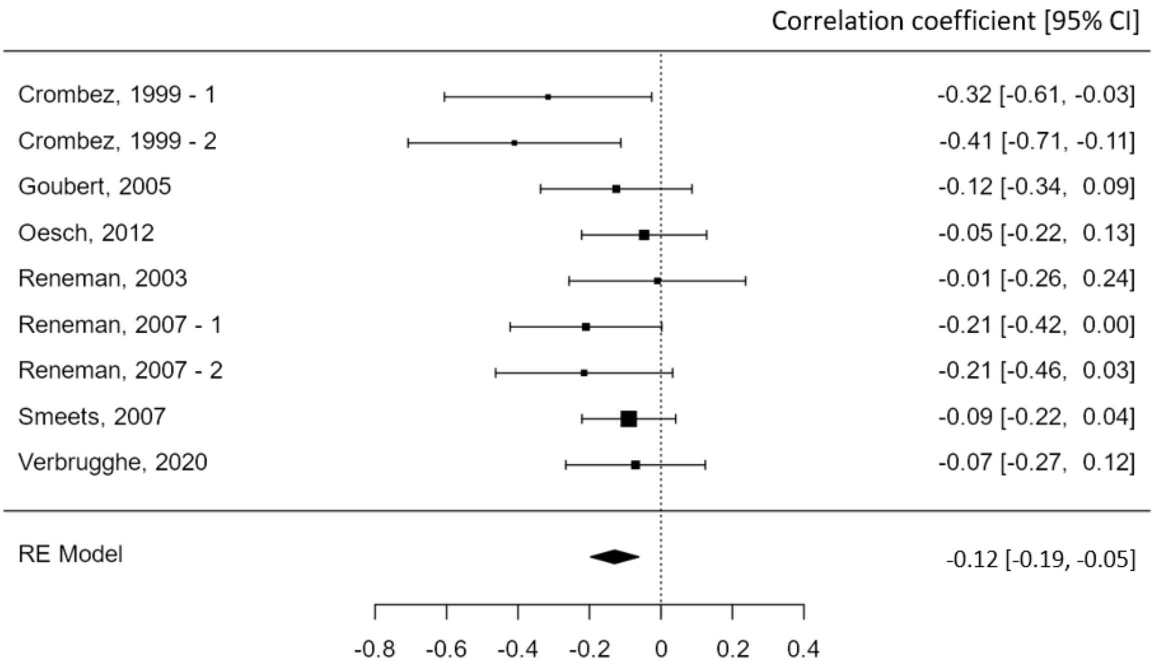
The pooled correlation coefficient was calculated by first transforming the correlation coefficients of the individual studies using a Fisher's z transformation. Meta-analyses were performed using the z-scores, after which an inverse Fisher's z transformation was used to obtain the pooled correlation coefficient and 95% confidence interval. This is the pooled correlation coefficient (95% CI) that is shown in each forest plot. For enhancing the clinical interpretation, the correlation coefficients with the 95% confidence interval (instead of ther than the z-scores) are shown for each individual study in the forest plots. Two separate studies (each in a different participant group) were reported in Crombez *et al* (1999) and Reneman *et al* (2007). In the forest plots, we refer to the respective first studies as Crombez, 1999 – 1 and Reneman, 2007 - 1, and to the second studies as Crombez, 1999 – 2 and Reneman, 2007 - 2.

Studies were included in these sensitivity analyses when they that had a low risk of bias on the risk of bias categories 'study confounding' and 'statistical analysis and reporting', and when they controlled for pain intensity. For a low risk of bias on study confounding, studies had to control for at least two of the following personal factors: sex, age or bodyweight (or bodyweight-related measures, such as body-mass index).

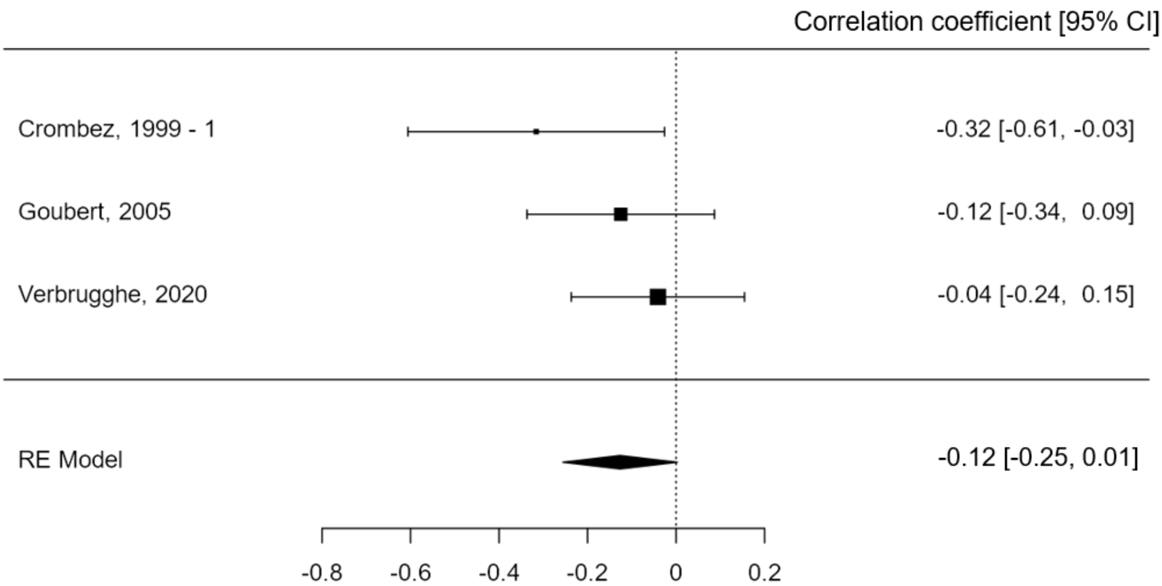
1. Pain-related fear

1.1 All questionnaires combined

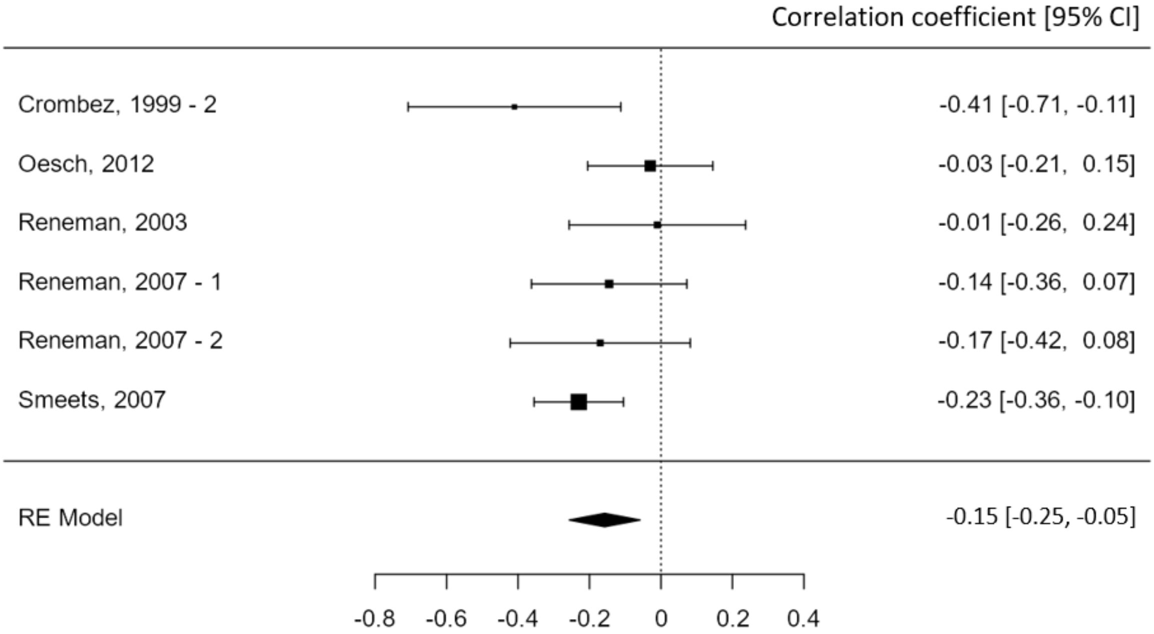
1.1.1 <u>Al studies combined</u>



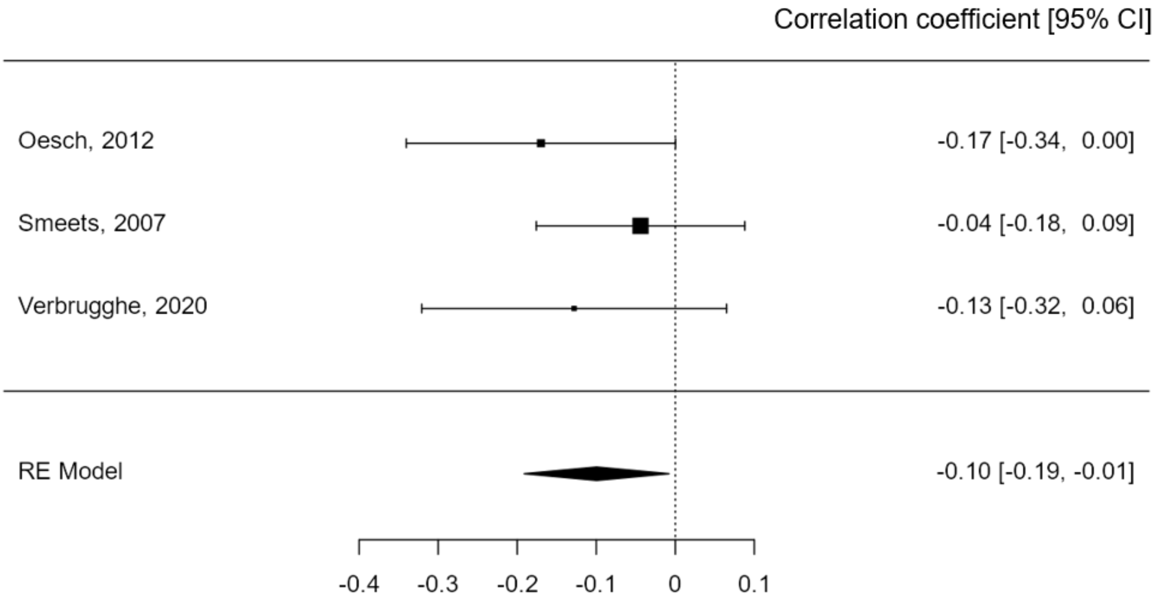
1.1.2 <u>Trunk muscle strength</u>



1.1.3 Lifting capacity

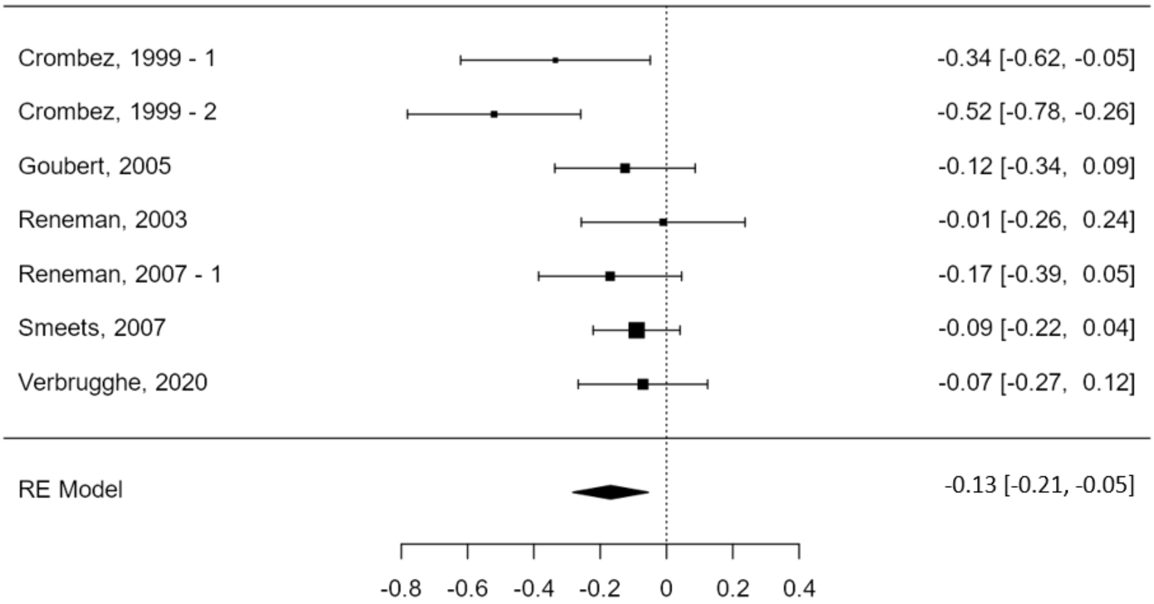


1.1.4 Functional mobility

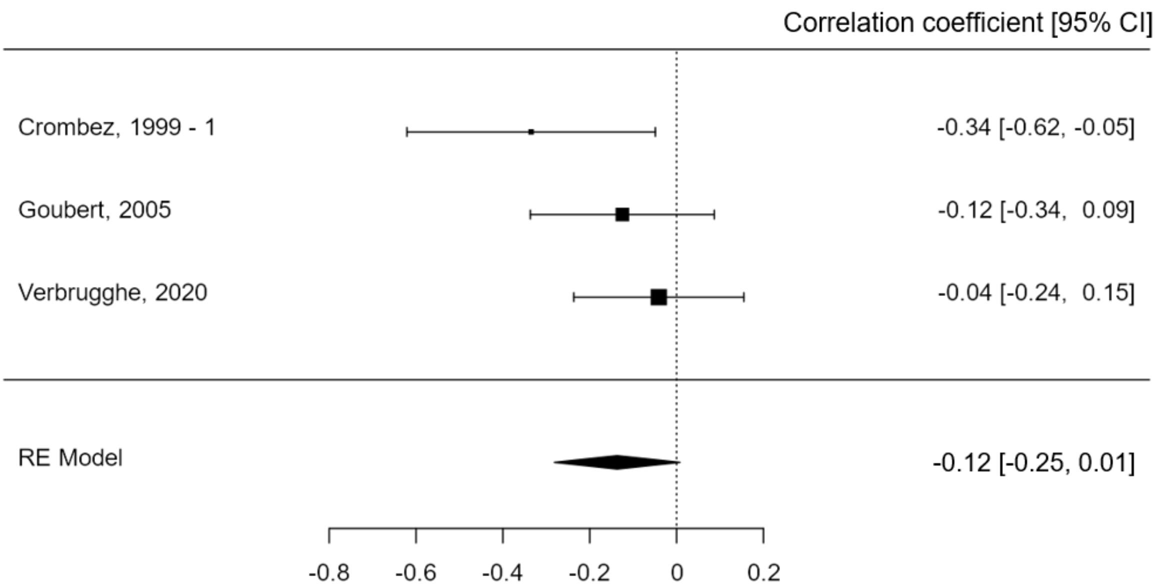


1.2 Tampa scale for Kinesiophobia – Total score

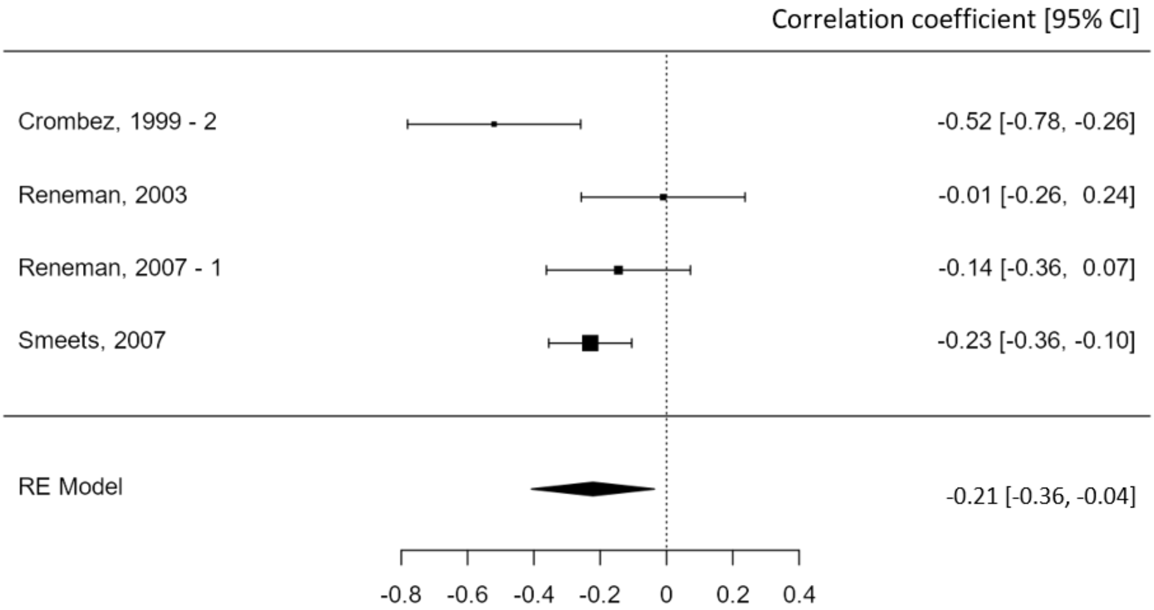
1.2.1 All studies combined



1.2.2 Trunk muscle strength



1.2.3 <u>Lifting capacity</u>



1.3 Fear Avoidance Beliefs Questionnaire – Work subscale

1.3.1 *All studies combined*