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Association of pain-related threat beliefs and disability with postural control and trunk motion in individuals with low back pain: A systematic review and Meta-Analysis

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Abstract

Purpose: Low back pain (LBP) individuals with high levels of fear of pain might display changes in motor behavior, which leads to disability. This study aimed to systematically review the influence of pain-related threat beliefs or disability on trunk kinematic or postural control in LBP.

Method: Eight electronic databases were searched from January 1990 to July 1, 2020. Meta-analysis using random-effect model was performed for 18 studies on the association between pain-related threat beliefs or disability and lumbar range of motion. Pearson r correlations were used as the effect size.

Result: Negative correlations were observed between lumbar range of motion (ROM) and pain-related threat beliefs ($r = -0.31$, $p < 0.01$, 95% CI: -0.39, -0.24) and disability ($r = -0.24$, $p < 0.01$, 95% CI: -0.40, -0.21). Non-significant correlations were reported between pain-related threat beliefs and center of pressure parameters during static standing in 75 % of the studies. In 33% of the studies, moderate negative correlations between disability and postural control were observed.

Conclusion: Motor behaviors are influenced by several factors, therefore the relatively weak associations observed between reduced lumbar ROM with higher pain-related threat beliefs and perceived disability, and postural control with disability are to be expected. This could aid clinicians in the assessment and planning rehabilitation interventions.

Keywords: fear of pain, catastrophizing, motor behavior, disability, low back pain

Introduction

Low back pain (LBP) is a common health problem with a high socio-economic burden [1]. Most LBP cases resolve within 8 to 12 weeks; however, in 15% of patients, it lasts for more than three months and specifies as chronic [2], accounting for major parts of disability and costs [3].

The cognitive-behavioral "fear-avoidance" model describes the role of pain-related threat beliefs in the development and maintenance of pain [4]. Individuals who perceive their pain as a sign of a severe threat to their body are likely to avoid painful activities and scan the body for sensations that may predict changes in pain [5]. Such protective behaviors are usually beneficial in the acute stage to minimize stress to the damaged tissues and enhance recovery [6]. However, these protective behaviors may paradoxically hinder functional recovery and eventually leads to disability development in the long term [7-9].

There is some evidence that individuals with LBP who display protective behaviors ultimately limit some movements or adjust their motor behavior [10-12]. Alteration in motor behavior could be evaluated by assessing kinematic measures of specific spinal segment or by evaluating the whole-body postural sway [13]. According to the fear-avoidance model, it is expected that LBP individuals with high pain-related threat beliefs show protective motor behavior by limiting lumbar spine ROM, velocity and acceleration of movement and reduced postural sway. Furthermore, altered spinal movements and postural control may also lead to higher perceived disability [14, 15]. However, evidence suggestive of such an association between motor behavior with pain-related threat beliefs and disability is inconsistent and not well-reviewed [16-20]. We aim to perform a systematic review and meta-analysis investigating both the association between pain-related threat beliefs and disability with trunk kinematic and postural control among LBP patients.

Methods

We conducted this systematic review according to the guidelines of preferred reporting items for systematic reviews and meta-analysis (PRISMA) [21]. The protocol was registered at the International Prospective Register of Systematic Reviews (PROSPERO: CRD42019132625).

Data Sources and Search Strategy

The search for publications was restricted to observational studies, according to the research question. Although randomized control trials provide the strongest evidence regarding an intervention, observational designs have long been used in the evaluation of the association between exposures and outcomes that might cause disease or injury [22]. The retrieved publications should have investigated the effect of pain-related threat beliefs or disability on the postural control or kinematics of trunk movement in subjects with acute or chronic primary LBP [23]. PubMed, Web of Science, Scopus, Cochrane Library, Google Scholar web search, Pedro, ProQuest and Embase electronic databases were searched from January 1990 to October 2019 and search was updated until July 1, 2020.The search strategy was designed using the medical subject heading (MeSH) terms, consisted of three groups of search terms including: 1) LBP, 2) pain-related threat beliefs/disability, 3) postural control/kinematic. A search syntax was created by the combination of MESH terms and keywords using OR and AND operators (Supplementary Appendix 1). A snowball search of the reference lists of the included studies was also conducted. The first author (SS) conducted the database search. Search results were exported to EndNote citation management software, and duplicates were removed. Two reviewers (SS and SSA) independently screened the exported studies by title and abstract to determine their relevance. The same reviewers assessed potentially relevant full-text articles against the eligibility criteria. Where the reviewers were uncertain or could not agree on the eligibility of individual studies, discrepancies were resolved by a third reviewer (RS).

Eligibility Criteria

Studies were included if 1) recruited adults (≥18 years of age) with acute and chronic primary LBP [23], 2) assessed pain-related threat beliefs or disability through standardized instruments, 3) the kinematics of movement was measured in the thoracic or lumbar region (e.g. range of motion (ROM), velocity and acceleration) or postural sway (center of pressure parameters (COP)) measured with a valid instrument, 4) accepted through peer-review. Studies were excluded if 1) recruited participants had any sign of specific LBP and previous spinal surgery 2) were review or case-studies, 3) association between pain-related threat beliefs or disability, with spinal kinematics or COP parameters were not adequately reported, 4) experimentally induced LBP.

Outcome measures

The pain-related threat beliefs measures included pain catastrophizing, fear-avoidance, fear of pain, fear of re injury and pain-related anxiety. The spinal motion comprises kinematics variables such as range, velocity and acceleration of the motion in any part of the thoracic and lumbar spine. The postural control variables were related to COP displacement.

Data Extraction

Two reviewers (SS and SSA) independently extracted the following data from the selected studies: study details, participant's information, duration and intensity of pain, pain-related threat beliefs or disability questionnaires and outcome, COP parameters, thoracic and lumbar spinal kinematics measurements, task description and correlation as a measure of effect size. Disagreements between reviewers were resolved by the third reviewer (RS).

Risk of Bias Assessment

The quality of included studies was assessed by two independent reviewers (SSA and RS), using the modified Downs and Black checklist to include criteria that were relevant to assess potential bias of the included studies [24]. The Downs and Black checklist was used with high intra-rater reliability ($r = 0.88$) and inter-rater reliability ($r = 0.75$) [25]. The qualitative rating was based on the percentage scores. The studies that achieved a score >66.8% were scored as high quality, 33.4 - 66.7% medium quality, and <33.3% as low quality [24].

Data Synthesis

For running the meta-analysis, the Pearson Correlation Coefficient (r) with 95% confidence intervals was used as the measure of the effect size of the linear association. Where studies reported Spearman, regression β coefficients and unstandardized regression value they were transformed to Pearson correlations using formulas [26] . If only mean and SD were available, then Cohen d was calculated and transformed into r.

In the present meta-analysis, the *random-effects models* were used as the true effect size could differ among studies due to divergent population characteristics in each study. The assumption of homogeneity of true effect sizes was assessed by the Cochran Q test. The degree of inconsistency across studies was assessed with I^2, which is calculated based on the percentage of total variation across studies. I^2 ranges between 0% (no inconsistency) and 100% (high heterogeneity), with values of 25, 50, and 75% suggesting low, moderate, and high heterogeneity [27]. In the case of high heterogeneity, sensitivity analysis was performed to determine the effect of each study on the pooled effect size. Egger's test was measured to statistically estimate the publication bias. Despite the existing debate over what constitutes a small, moderate and large effect, we adopted the criterion that correlation coefficients of 0.10 to <0.30, 0.30 to <0.50, and >0.50 represent weak, moderate and strong associations, respectively [28].

Pooling and analysing the combined effects were performed if at least four studies met the inclusion criteria and determined to have a similar methodology (same outcome measures and same testing condition). Subgroup analysis was performed based on the quality of the study, direction of motion, and the stage of LBP acute/subacute. In the case of high methodological heterogeneity between studies, the outcome measures were interpreted in a narrative synthesis.

Results

The study selection process is presented in the PRISMA flow diagram in Figure 1. We retrieved 6636 articles, which after removing 1631 duplicates, 5005 titles and abstracts were scanned for relevance. Full texts of 135 potentially relevant articles were evaluated. Finally, 26 articles were included in this review, and of them, 18 studies related to pain-related threat beliefs or disability and kinematics of spinal movement were included in the meta-analysis.

Assessment of risk of bias

The quality of the included studies varied from low (2 studies: 7.40%), to medium (13 studies: 48.14%), and high (11 studies: 44.44%) (See Table 1). Figure 2 demonstrates the risk of bias for all 26 included studies. High risk of bias was identified for assessor blindness and sample selection. More than about 50% of the sample came from studies without the assessor blindness and controlling for confounding factors. In addition, inadequate sample size justification (power calculation) was observed in the studies.

Study characteristics

We synthesized findings into two separate meta-analyses and three narrative reviews based on the included studies (Figure 3) (Table 2, 3, 4). Eight studies on the effects of pain-related threat beliefs and lumbar ROM were included in the first meta-analysis [29-36]. Seven studies examined participants with primary chronic LBP [29-34, 36], and three studies investigated participants with acute/subacute LBP [29, 30, 35]. All studies included a spinal flexion task. The second meta-analysis included 15 studies on the association between lumbar spine ROM and disability [14, 30, 32, 34, 36-46]. The ROM assessments were in various movement directions (flexion: 15, extension: 6, lateral flexion: 6 and rotation: 4 studies). The narrative systematic review included seven studies on the association between pain-related threat beliefs on postural sway (COP parameters) [14, 18, 47-51] and five studies assessed the association between postural sway and disability [14, 15, 47, 48, 51]. All studies assessed static postural control, and two of them evaluated dynamic postural control additionally [14, 49]. The most used outcome measures were COP mean velocity, COP range of displacement in the anterior-posterior and medial and lateral direction, and COP sway area for static conditions and limits of stability velocity and excursion for dynamic testing conditions. Testing conditions varied based on sensory input manipulations such as omitting vision (eyes open or closed) and disturbing proprioception inputs using foam, unstable surface and ankle vibration.

Meta-analysis findings

Pain-related threat beliefs and Lumbar ROM

The overall results in the meta-analysis revealed a moderate negative correlation between pain-related threat beliefs and flexion ROM $r = -0.31$, $p < 0.01$, 95% CI [-0.39, -0.24] with low heterogeneity across studies ($I^2 = 3\%$). Sub-group analysis based on the stage of LBP revealed moderate correlation $r = -0.41$, 95% CI [-0.55, -0.24], ($I^2 = 19\%$) between pain-related threat beliefs and flexion ROM in back pain < 3 months, and low associations for those with back > 3 months' $r = -0.26$, 95% CI [-0.36, -0.15], ($I^2 = 0\%$) (Figure 4). Subgroup analysis based on the quality of the studies did not affect the results. The sensitivity analysis suggested that the combined r was stable after each study was excluded one by one from the current meta-analysis. Egger's regression test $p = 0.86$, 95% CI [-1.44, 1.73] revealed no evidence of publication bias.

Disability and ROM

The overall results of fifteen studies assessing the effects of disability on lumbar ROM [30, 32-43, 45, 46], showed an inverse relationship with disability $r = -0.24$, $p < 0.01$, 95% CI [-0.40, -0.21] with moderate heterogeneity $p < .01$, ($I^2 = 61\%$). Subgroup analyses based on motion direction substantially reduced heterogeneity only for lateral flexion. The association between lumbar flexion ROM and disability was $r = -0.26$, 95% CI [-0.38, -0.14], ($I^2 = 66\%$), extension $r = -0.18$, 95% CI [-0.37, -0.02], ($I^2 = \%75.8$), lateral flexion $r = -0.32$, 95% CI [-0.39, -0.24], ($I^2 = 0\%$) and rotation $r = -0.10$ 95% CI [-0.40, 0.21], ($I^2 = 80\%$) (Figure 5). Subgroup analysis based on the quality of the studies did not change the result. Furthermore, a sensitivity analysis, by removing each study from the meta-analysis one by one, revealed no difference in the magnitude and direction of the pooled effect size. This indicates that the observed results are statistically robust. Egger's regression test $p = 0.317$, 95% CI [-5.24, 1.57] revealed no evidence of publication bias.

Narrative synthesis findings

Pain-related threat beliefs, velocity and acceleration, and disability

Three studies assessed the correlation between pain-related threat beliefs and lumbar movement velocity [31, 32, 35], with two studies reporting a significant negative, weak and moderate association between peak lumbar velocity in flexion direction and FABQ [31, 35]. Three studies assessed the correlation between lumbar movement velocity and disability [35, 43, 46], in which no relationship was reported. Two studies assessed the association between lumbar movement acceleration and pain-related threat beliefs and disability, and both reported a moderate negative correlation [31, 32].

Pain-related threat beliefs, postural control, and disability

As the testing conditions and outcome measures varied substantially across postural sway studies, therefore doing meta-analysis was not feasible. Non-significant correlations were reported between pain-related threat beliefs and COP parameters during standing in 75 % (6/8) of the studies. Two studies reported a moderate but significant negative correlation, which assessed postural control with performing a cognitive task [50] and dynamic postural control [51]. Overall, 50% (3/6) of the studies reported correlations between disability and postural sway in one of the testing conditions [14, 15, 47]. Two studies (33%) reported moderate negative associations [14, 15], and one study (17%) found a poor positive correlation [47]. These associations were evident for static standing on a firm surface with or without vision for COP mean velocity [15, 47] and limits of stability movement velocity for dynamic postural control [14].

Discussion

Pain-related threat beliefs and lumbar ROM

This meta-analysis revealed overall significant moderate negative correlations between pain-related threat beliefs and lumbar flexion ROM. Nevertheless, subgroup analysis based on LBP duration revealed a moderate negative association in the acute/subacute and weak association in the chronic stage. It is plausible that LBP individuals with higher levels of pain-related threat beliefs and associated pain-related fear and anxiety restrict their flexion ROM to prevent pain. This avoidance behavior could be more obvious in the acute/subacute LBP phase. At this stage of the normal recovery, avoidance behaviors are likely to protect the tissues from further injury [52]. The transition from acute to chronic stage involves the learning of which body postures or movements are associated with pain and hence are consequently avoided [53, 54]. The studies in this review only used flexion tasks for the assessment of movement, which might not be predictive of pain in all CLBP patients necessarily, therefore not trigger avoidance behavior. Although associative learning starts at the acute onset of the pain problem, the prediction of pain might not always be accurate in this stage [55]. Therefore, pain-related behaviors commonly in the early stages might be generalized to all directions of movement in an attempt to protect the body from re injury and allow healing. In addition, most studies have measured pain-related beliefs (such as fear of movement) by general and non-task specific questionnaires [33]. To some extent, such discrepancy could explain the lower association between pain-related threat beliefs and lumbar ROM at the chronic stage.

Lumbar ROM and disability

The overall result of the meta-analysis on the association between lumbar ROM and disability revealed a weak and negative correlation with reduced lumbar ROM related to more disability. Most of the included studies evaluated maximum ROM an individual with LBP could achieve, which could explain this modest correlation. However, the active ROM required for performing daily activities is considerably less than a full range of motion [56], and disability is defined as any restriction or lack of ability to perform daily activities within the range considered normal for a human [57]. Hence the inability to complete the full active ROM might not considerably impact daily activities in individuals with LBP, explaining the relatively mild association between trunk ROM and score of disabilities.

Subgroup analysis based on movement direction conclusively demonstrated a higher association between the lateral flexion ROM and disability. In line with our finding, another meta-analysis reported reduced lateral flexion ROM as a predictor of LBP development compared to other directions [58]. The full active ROM of flexion/extension is larger than lateral flexion in a healthy population; however, performing daily activities involves a greater proportion of lateral flexion ROM [56, 59]. Thus, limited lateral trunk movement might influence daily activities to a greater extent than sagittal plane motions. Hence, we suggest the potential importance of lateral trunk movement in patients' assessment and treatment, most likely predictive of the patient's disability.

Based on the predefined cutoff scores established for the instruments, the included individuals in most studies were not well distributed from all levels (low to high) of pain-related threat beliefs and perceived disability. Hence, the restriction of individuals variation in regard to these factors could explain lower variations in kinematics and possibly influence the correlation coefficients [60].

Pain-related threat beliefs and postural sway

The high methodological heterogeneity of the studies on the association of pain-related threat beliefs, postural control, and disability did not allow us to perform a meta-analysis. The COP measures of postural control revealed poor or no associations with pain-related threat beliefs. Only two of the studies found moderate negative correlations, which one was conducted under dynamic standing [51] and another assessed postural sway while performing a secondary cognitive task (dual-task) [50].

Several concerns are related to the findings of the studies performed under static standing. First, the standard instruction to stand as still as possible used in most studies might induce conscious monitoring of the body sway. These laboratory instructions may influence the neuromuscular control of the upright stance and consequently minimize spontaneous postural sway [61-63].The steadiness requirement of these instructions might have reduced the between-subjects' variability, as every individual behaves the same irrespective of the level of pain-related threat beliefs [64]. Under dynamic situations or when performing a secondary cognitive task, postural sway's conscious control would become difficult. Therefore, the type of postural task performed might also affect the association between pain-related threat beliefs and postural sway.

Disability and postural sway

The results revealed a significant and negative correlation between disability and postural control in 33% of the studies, which found reduced postural sway in more disabled individuals with LBP [14, 15] during open eyes condition. The data available is insufficient to determine whether some form of correlation between LBP disability and the magnitude of postural sway exists. In addition, several diverse testing conditions with and without sensory manipulations were used by the studies, which makes it difficult to compare the findings between studies. Only COP sway velocity showed association with disability, highlighted as the most reliable postural sway outcome measure [65, 66]. This is noteworthy that the reported level of LBP perceived disability was mostly low, which might not be a true representative of the LBP population. Therefore, it could not be concluded whether greater perceived disability might influence static and dynamic posture maintenance.

The interpretation of the magnitude of effect sizes was based on Cohen's criteria, whereas clinical and practical use of this benchmark has been criticized in applied psychology. Several researchers have suggested a revision of Cohen's standards, considering greater than 0.20 and greater than 0.30 as medium and large [67-69]. Bosco et al. recommended varying benchmarks across bivariate relationships in psychology and yielded substantially lower associations for relations involving behaviors than others [67]. Motor behaviors are influenced by several factors such as motivation, attention, environmental and cultural context [70, 71]. Hence, it is unlikely in a correlational behavioral study that one factor alone can explain a substantial amount of the variance in the outcome with a high effect size. For this reason, the relatively weak associations observed between reduced lumbar ROM with higher pain-related threat beliefs and perceived disability, and postural control with disability are to be expected. Clinicians should take into account evaluating pain-related threat beliefs and disability in LBP individuals with limited ROM and poor postural control, therefore, designing interventions according to the self-perpetuating vicious cycle of pain-related threat beliefs, avoidance behavior and disability [9]. Nevertheless, from the findings of the present systematic review this question remains, whether clinicians should target pain-related threat beliefs to increase ROM (cognitive behavior therapies), or to gradually increase ROM by exposing individuals to the tasks being avoided (graded exposure intervention) to eventually decrease the perceived disability.

Limitation and future directions

The current meta-analyses and narrative reviews also have their limitations. First, the cross-sectional and correlational nature of the included studies provides a limited basis to infer causality. Second, most of the studies did not present a pre-study sample size calculation, thus inducing a possible increased risk of estimation bias due to lack of statistical power. Too small sample sizes may also reduce the representativeness of samples (e.g., in terms of sociodemographic and severity of the disease), which could increase the risk of bias and likely affect the strength of the associations under study. Third, the inclusion of individuals with lower levels of pain-related threat beliefs and disability could lead to misclassification and reduces the generalizability of the overall correlation. This could reflect the challenges for including participants with higher levels of pain-related threat beliefs and perceived disability. Hence, future studies are required that include LBP individuals with ranges of patients with low to high levels of pain-related threat beliefs and disability. Finally, kinematic parameters were mainly limited to flexion movement types or non-functional single plane movements, and also postural control studies were limited to static conditions. Therefore, since not all individuals are likely fearful of flexion movement, and disability is better to be evaluated during functional task, it is recommended to use functional task for kinematic and postural control measures that resemble daily functions, and also using task-specific measurement are recommended in future scientific studies.

Conclusion

This study showed moderate negative correlations between pain-related threat beliefs and lumbar flexion ROM and weak negative association between lumbar ROM and disability in LBP individuals. Most of the studies reported no association between pain-related threat beliefs and postural control (COP parameters). However, one-third of studies reported a significant negative relationship between postural control and disability.

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Author contributions

SS, SSA, IET conceived, planned, and designed the study. SS, SSA searched databases, screened title/abstract and full text and extracted the data. SSA, RS contributed to risk of bias assessment. HJ, SS, RS, contributed to data analysis. SS, SSA, IET, HJ, JWSV contributed to the interpretation of the results and drafting the article. JWSV, SS, RS, HJ provided critical feedback and revising and providing the final version of the manuscript, all authors have approved the final version.

Figure 1. Flow diagram of study selection process. ROM: Range of Motion

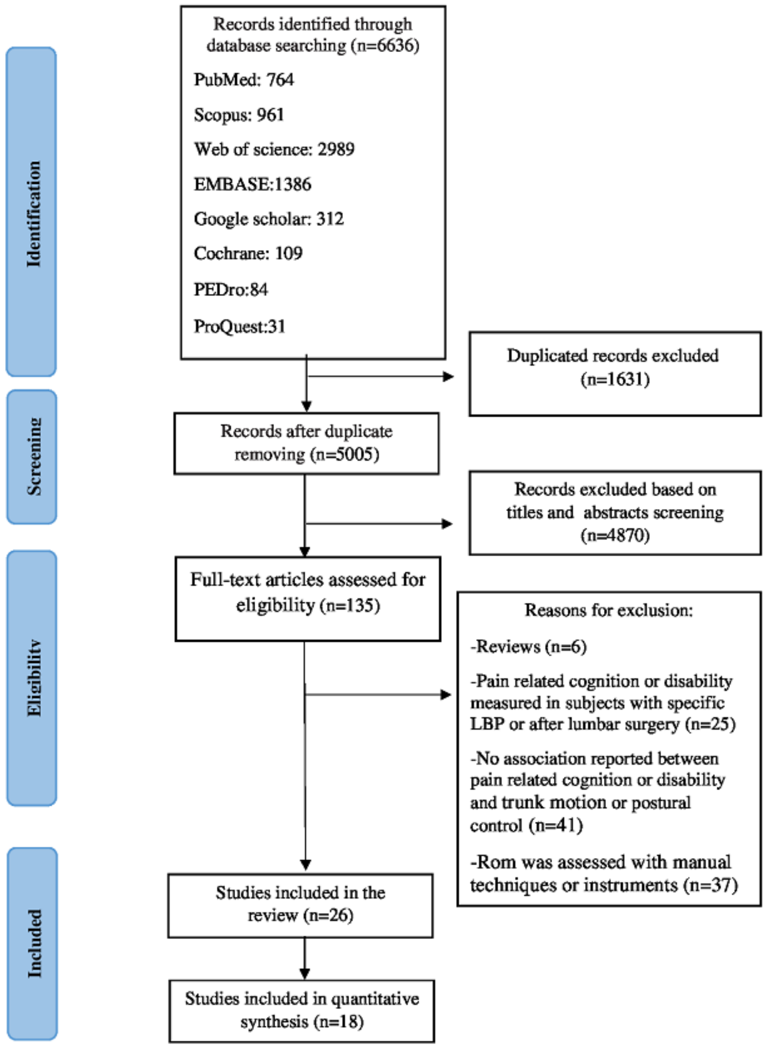


Figure 2. Risk of bias assessment

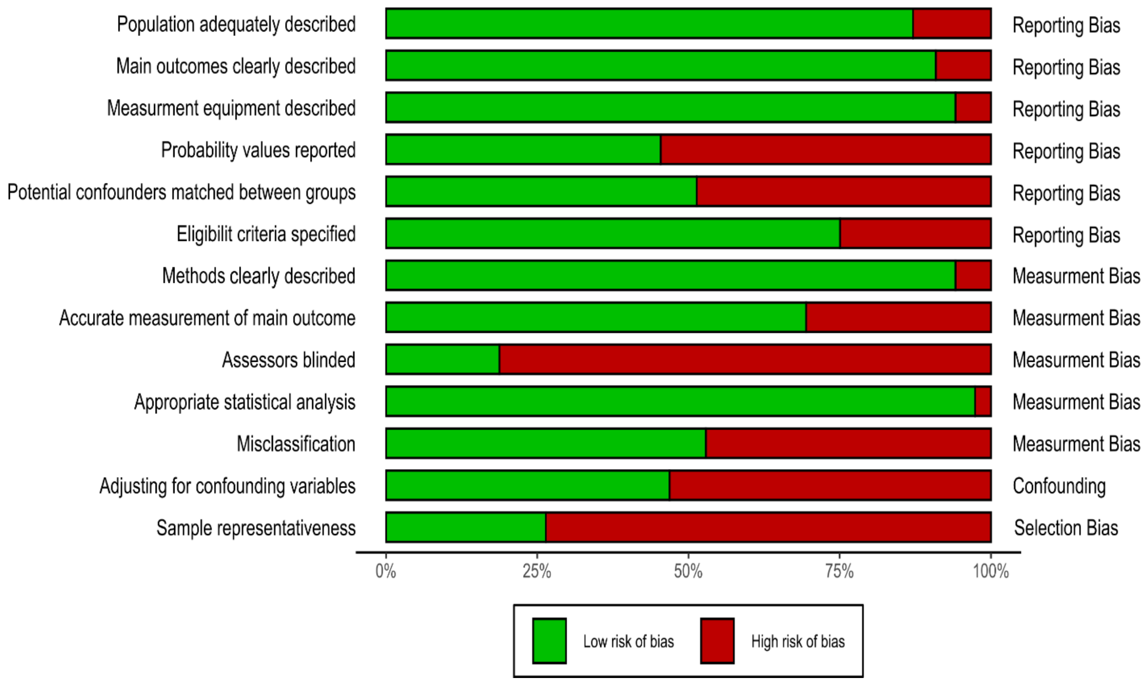


Figure 3. The diagram of the narrative/systematic review, meta-analysis and their corresponding associations were covered in this study. Link A shows the first meta-analysis performed on the association of pain-related threat beliefs and trunk kinematic (range of motion). Link B is the second meta-analysis performed in this study which covers the effect of trunk kinematics on disability

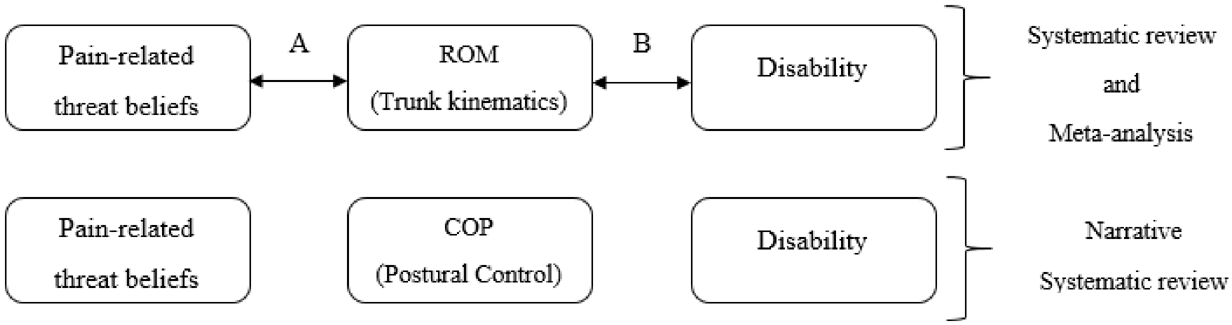
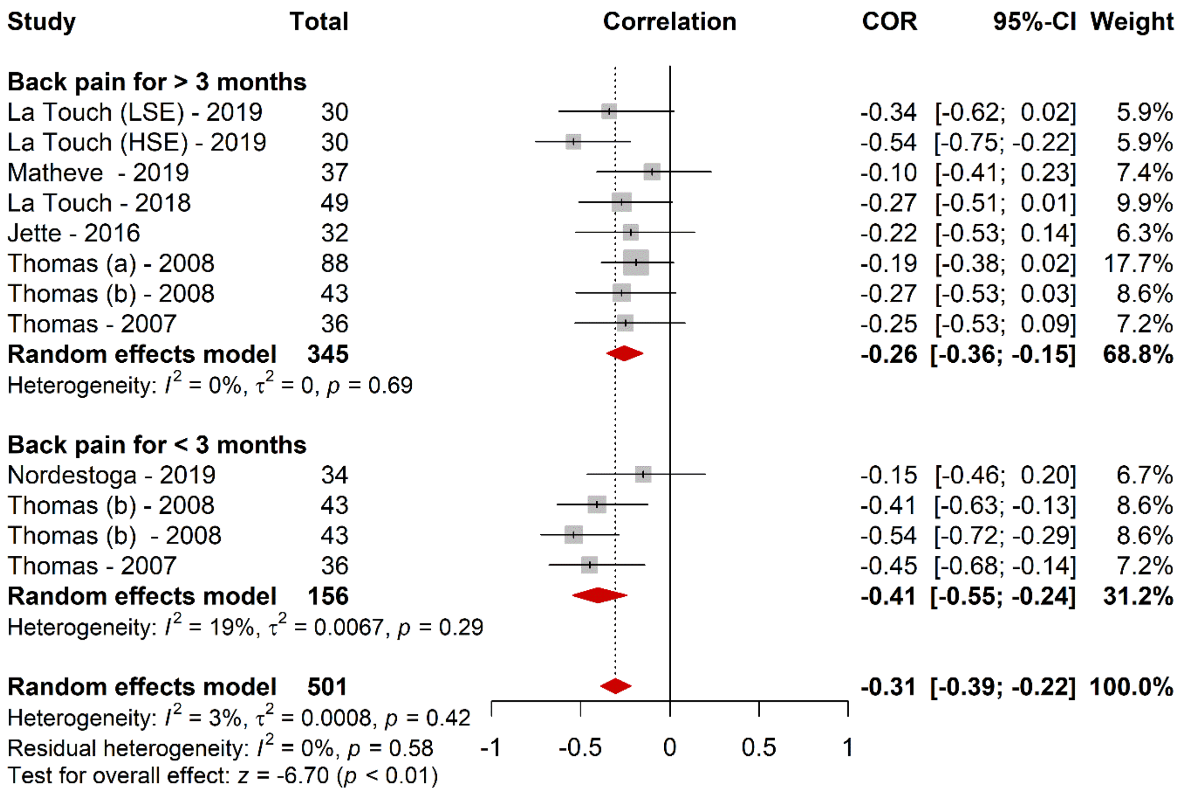


Figure 4. Forest plot of the correlations between pain-related threat beliefs and flexion ROM in sub-groups of LBP subjects. The effect size for LBP > 3 months was r = -0.26, 95% CI [-0.36, -0.15], (I2 = 0%) in for those with LBP < 3 months' r = -0.41, 95% CI [-0.55, -0.24], (I^2 = 19%).



LSE: Low self-efficacy, HSE: High self-efficacy

Figure 5. Forest plot of the correlations between disability and lumbar range of motion in LBP subjects. The effect size for disability and lumbar flexion ROM: *r* = -0.26, 95% CI [-0.38, -0.14], (I^2 = 66%), extension *r* = -0.18, 95% CI [-0.37, -0.02], (I^2 = %75.8), lateral flexion *r* = -0.32, 95% CI [-0.39, -0.24], (I^2 = 0%) and rotation *r* = -0.10 95% CI [-0.40, 0.21], (I^2 = 80%).

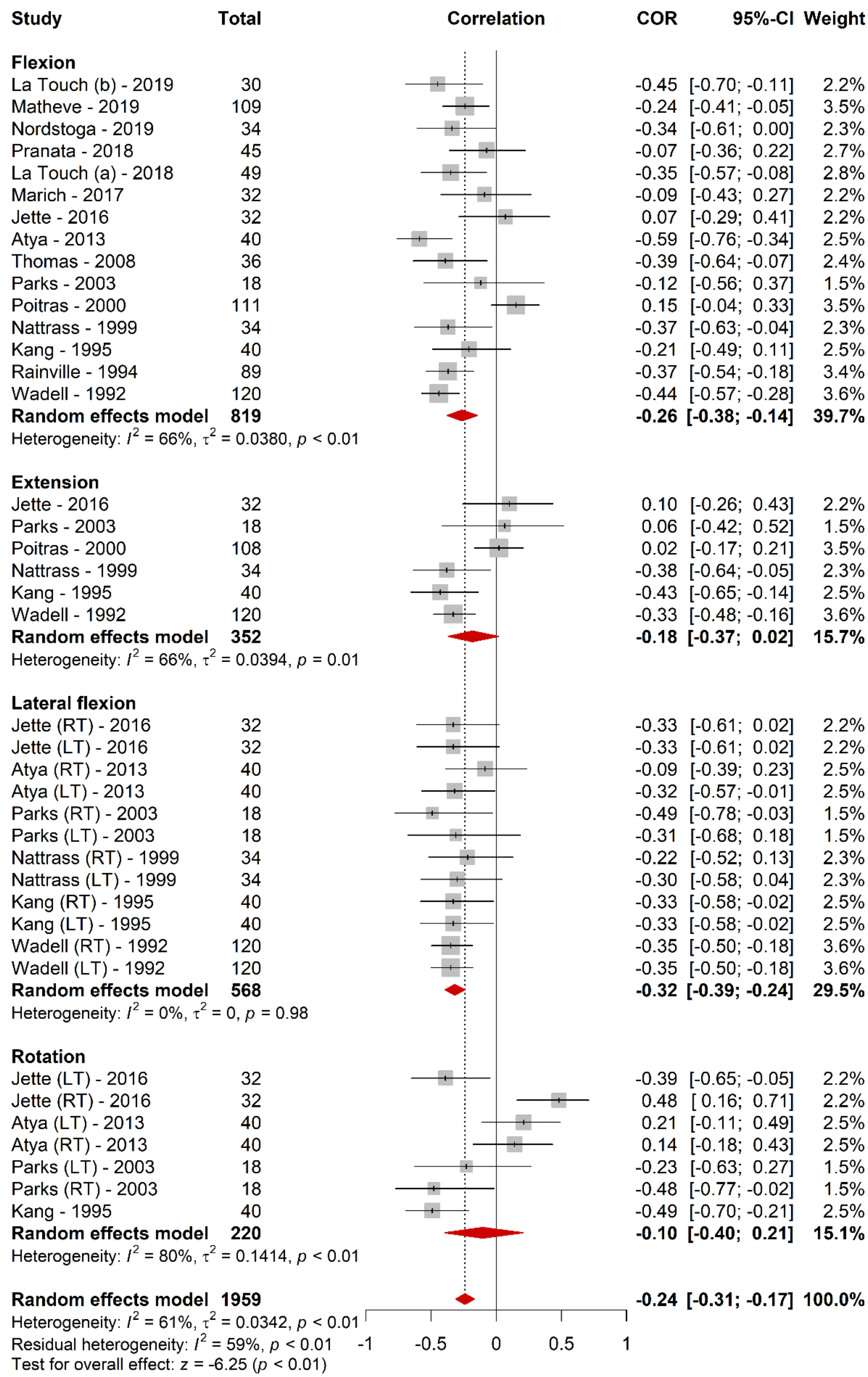


Table 1: Quality assessment of the included studies

	Reporting						Measurement bias					Confounding	Selection bias	Power		
Study	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Quality	Percent score
Waddell et al. (1992)	Y	Y	Y	Y	N	Y	Y	Y	N	Y	N	N	N	N	Medium	57.14
Rainville et al. (1994)	Y	N	N	N	N	Y	N	N	N	Y	N	N	N	N	Low	21.428
Kang et al. (1995)	N	Y	Y	N	N	N	Y	N	N	Y	N	N	N	N	Low	28.571
Nattrass et al. (1995)	Y	Y	Y	N	N	N	Y	Y	N	Y	Y	N	N	N	Medium	50
Poitras et al. (2000)	N	Y	Y	N	Y	N	Y	Y	Y	Y	Y	N	Y	N	Medium	57.142
Parks et al. (2003)	Y	Y	Y	N	N	N	Y	N	N	Y	N	N	N	N	High	71.428
Thomas et al. (2007)	Y	Y	Y	N	Y	N	Y	Y	N	Y	Y	Y	N	N	Medium	64.28
Thomas et al. (2008a)	Y	Y	Y	N	Y	Y	Y	Y	N	Y	Y	Y	Y	N	High	71.42
Thomas et al. (2008b)	Y	Y	Y	Y	N	N	Y	Y	N	Y	Y	Y	N	N	High	78.571
Brech et al. (2012)	Y	Y	Y	Y	N	Y	N	Y	N	Y	N	N	N	N	Medium	50
Maribo et al. (2012)	Y	Y	Y	N	N	N	Y	Y	Y	Y	N	N	Y	N	Medium	57.142
Champagne et al. (2012)	Y	Y	Y	N	Y	Y	Y	Y	N	Y	N	Y	N	N	Medium	50
Atya et al. (2013)	Y	Y	Y	N	Y	Y	Y	Y	N	Y	N	Y	Y	Y	Medium	57.142
Davis et al. (2013)	Y	Y	Y	Y	N	Y	Y	N	N	Y	Y	Y	N	Y	Medium	64.285
Sung et al. (2013)	Y	Y	Y	N	Y	Y	Y	Y	N	Y	N	N	N	N	High	78.571
Mazaheri et al. (2014)	Y	Y	Y	N	Y	Y	Y	Y	N	N	N	N	N	N	High	71.428
Sung et al. (2015)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Medium	57.142
Jette et al. (2016)	Y	Y	Y	N	N	Y	Y	N	N	Y	N	N	Y	Y	Medium	50
Marich et al. (2017)	Y	Y	Y	N	Y	Y	Y	Y	N	Y	Y	Y	N	Y	High	85.714
Shanbehzadeh et al. (2018)	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	N	N	Medium	57.142
Pranata et al. (2018)	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	N	N	N	High	78.571
La Touche et al. (2018)	Y	N	Y	Y	Y	Y	Y	N	N	Y	N	N	N	Y	High	78.571
Ozcan Kahraman et al. (2018)	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	N	N	N	Y	High	71.428
Nordstoga et al. (2019)	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Medium	57.142
Matheve et al. (2019)	Y	Y	Y	N	Y	Y	Y	Y	N	Y	Y	Y	N	N	High	71.428
La Touche et al. (2019)	Y	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Y	N	N	High	78.571

Y: Yes, N: No, 1: Is the study population adequately described? 2: Are the main outcomes to be measured and the related calculations (if applicable) clearly described? 3: Is the measurement equipment adequately described? 4: Have actual probability values been reported except where the probability value is <0.001 and including confidence intervals? 5: Are the distributions of principal confounders in each group of subjects to be compared clearly described? 6: Are the characteristics of the patients included in the study clearly described? 7: Is the measurement procedure clearly described? 8: Were the main outcome measures used accurate method (standardizing instructions, reliable and valid tool)? 9: Are assessors blind to the group allocation? 10: Are the statistical tests used to assess the main outcomes appropriate? 11: Were there any attempts made to reduce bias related to exposure misclassification? 12: Is there adequate adjustment for confounding in the analyses from which the main findings were drawn or study design? 13: Are the subjects asked to participate in the study representative of the entire population from which they were recruited? 14: Is power description represented for sample size justification?

Table 2. Details of studies investigating the effects of pain-related threat beliefs on trunk motion

Study	Health status/ n	Age in years	Pain level scale: mean	Disease duration	Pain-related threat beliefs scale: mean (SD)	Disability scale: mean (SD)	Device/variable	Task/condition	Result
Thomas et al. (2007)	LBP/ 36	Low pain-related threat beliefs subjects:24.9	MPQ: low pain-related threat beliefs subjects: 8.6	3 weeks	PASS: low Pain-related threat beliefs subjects: 38.0 (14.1)	RDQ: low pain-related threat beliefs subjects: 4.2 (2.8)	Motion analyzer / ROM	Forward reach	Significant moderated correlation in the acute/subacute stage.
		High Pain-related threat beliefs subjects: 28.8	High pain-related threat beliefs subjects: 10.2		High pain-related threat beliefs subjects: 78.5(10.3)	High pain-related threat beliefs subjects: 10.2 (5.9)			
Thomas et al. (2008a)	LBP/88	30.9	Pain-free for 4 weeks after a recent episode of LBP	NR	TSK: 35.4 (0.6) PASS: 16.1 (0.6)	-	Motion analyzer /ROM, velocity, acceleration	Forward reach	No significant correlation for ROM Significant moderate correlation for velocity of movement.
Thomas et al. (2008b)	LBP/36	26.9	MPQ: 9.4	3 weeks	TSK: 36.9 (7.8) PASS: 58.3 (23.9) PCS:15.1 (9.3)	RDQ:7.2 (5.9)	Motion analyzer /ROM	Forward bending from standing position	Significant moderate correlation
Jette et al. (2016)	NCLBP/32	32.94	VAS: 2.00	>3 months	FABQ: 33.25 (9.48)	ODI: 19.02 (8.72)	Human Motion tracker, /ROM, velocity, acceleration	Flexion, extension, lateral flexion and rotation of lumbar, from standing position	Significant poor to moderate correlations

Table 2. continued.

Study	Health status/ n	Age in years	Pain level scale: mean	Disease duration	Pain-related threat beliefs scale: mean (SD)	Disability scale: mean (SD)	Device/variable	Task/ condition	Result
Nordstoga et al. (2019)	Current NLBP/44	42.8	NPRS: 5.4	NR	FABQ-PA: 8.8 (5.3) FABQ-W: 11.3 (10.4)	ODI: 23.6 (12.4)	Motion analyzer /ROM, velocity	Flexion and extension of lumbar, from standing position	Significant Poor correlations
Matheve et al. (2019)	NCLBP/55 Control/44	NCLBP:41.1 Control: 36.9	NPRS: 4.6	>3 months	TSK: 36.5 (6.9)	RDQ: 7 (range: 5–11)	Motion analyzer / ROM	Lifting from standing position	Significant poor correlation
La Touche et al. (2019)	NCLBP/60	NCLBP with high self-efficacy: 38.17 NCLBP with low self-efficacy: 36.53	VAS: NCLBP with high self-efficacy: 3.95 NCLBP with low self-efficacy: 4.41	>6 months	TSK: NCLBP with high self-efficacy:22.23 (6.92) NCLBP with low self-efficacy: 29.43 (5.22) PCS: NCLBP with high self-efficacy: 8.07 (5.66) NCLBP with low self-efficacy:17.50 (7.95) FABQ: NCLBP with high self-efficacy: 20.13 (10.52) NCLBP with low self-efficacy: 32.50 (14.21) CPSS: NCLBP with high self-efficacy: 174.77 (6.53) NCLBP with low self-efficacy: 138.53 (14.91)	RDQ: NCLBP with high self-efficacy: 4.57 (1.61) NCLBP with low self-efficacy: 5.9 (1.68)	Inclinometer /ROM	Lumbar range of motion,	Strong correlation between Pain-related threat beliefs and lumbar range of motion

CLBP: chronic low back pain, CPSS: chronic pain self-efficacy scale, FABQ: fear avoidance beliefs questionnaire, FABQ-PA: fear avoidance beliefs related to physical activity, FABQ-W: fear avoidance beliefs related to work, LBP: low back pain, MPQ: McGill Pain questionnaire, NCLBP: nonspecific chronic low back pain, NLBP: nonspecific low back pain, NPRS: numeric pain rating scale, NR: not reported, ODI: Oswestry disability index, PASS: Pain Anxiety Symptoms Scale, PCS: pain catastrophizing scale, RDQ: Rolland-Morris disability questionnaire, ROM: range of motion, TSK: Tampa scale for kinesiophobia, VAS: visual analogue scale

Table 3. Details of studies investigating the effects of disability on trunk motion

Study	Health status/ n	Age in years	Pain level scale: mean	Disease duration	Pain-related threat beliefs scale: mean (SD)	Disability scale: mean (SD)	Device/variable	Task/condition	Result
Waddell et al. (1992)	CLBP/120 Control/70	CLBP:34.9 Control: NR	VAS: NR MPQ: NR	>3 months	-	RDQ: NR	NR/ ROM	Lumbar flexion, extension and lateral flexion	Significant moderate correlation
Rainville et al. (1994)	CLBP/75	38	VAS: 7	>3 months	-	MVAS: 105	Inclinometer / ROM	Lumbar flexion and total trunk flexion	Significant moderate correlation.
Kang et al. (1995)	CLBP/40	46.9	PDI: NR	>6 months	-	RDQ: NR	Electrogoniameter / ROM	Lumbar lateral flexion, extension and rotation	Significant poor correlation.
Nattrass et al. (1999)	CLBP/34	43.9	VAS: NR	✪6 months	-	ODI:39.5 (15.3) WDI:6.2 (2.3)	Goniometer, Dual inclinometer / ROM	Lumbar lateral flexion, extension and rotation	Significant poor to moderate correlation.
Poitras et al. (2000)	LBP/111	40.4	-	4-week, 12 week	-	ODI:30.4 (15.5)	Motion analyzer/ ROM, Velocity	Trunk flexion, extension	Significant poor to moderate correlation.
Parks et al. (2003)	CLBP/18	35.7	-	5 months to 7 years	-	ODI: NR	Motion analyzer/ ROM	Lumbar flexion, extension, lateral and axial rotation	Significant poor correlation
Atya et al. (2013)	NCLBP/50	30	VAS:8.07	>6 months	-	RDQ: 6.85 (3.5)	Inclinometer, Goniometer-compass / ROM	Lumbar flexion, extension, lateral flexion and rotation	Significant poor to moderate correlation
Davis et al. (2013)	CLBP/235	32	NPRS:3	> 3 weeks	FABQ-PA: 14 (range 0-24) FABQ-W: 15 (range 0-40) TSK: 33 (range 18-63)	MODI: CLBP with high disability> 20 CLBP with low disability<20	Inclinometer	Lumbar flexion	No significant correlation
Sung et al. (2013)	NCLBP/15 Control/15	LBP:37.15 Control:41.82	-	>2 months	-	ODI: 21.66 (7.44)	Motion analyzer/ ROM	Squat	No significant correlation
Marich et al. (2017)	CLBP/32 Control/16	CLBP with high disability: 36.2 CLBP with low disability: 38.6 Control: 37.4	NPRS: CLBP with high disability: 3.2 CLBP with low disability: 2.9	✪12 months	FABQ-PA: CLBP with high disability: 12.6 (8.5) CLBP with low disability: 5.4 (6.9) FABQ-W: CLBP with high disability: 14.7 (5.6) CLBP with low disability: 9.8 (4.7)	MODI: CLBP with low disability: 12.0 (4.4) CLBP with high disability: 33.8 (8.7)	Motion analyzer/ lumbar excursion	Pick up an Object	Significant poor to moderate correlation.

CLBP: chronic low back pain, CPSS: chronic pain self-efficacy scale, FABQ-PA: fear avoidance beliefs related to physical activity, FABQ-W: fear avoidance beliefs related to work, LBP: low back pain, LOS: limit of stability, MODI: modified Oswestry disability questionnaire, MPQ: McGill pain questionnaire, MVAS: million visual analogue scale pain disability index, mVel: mean velocity, NCLBP: nonspecific chronic low back pain, NPRS: numeric pain rating scale, NR: not reported, ODI: Oswestry disability index, PDI: pain disability index, ROM: range of motion, RDQ: Rolland-Morris disability questionnaire, TSK: Tampa scale for kinesiophobia, VAS: visual analogue scale, Vel: velocity, WDI :Waddell disability index.

Table 3. continued

CLBP: chronic low back pain, CPSS: chronic pain self-efficacy scale, FABQ-PA: fear avoidance beliefs related to physical activity, FABQ-W: fear avoidance beliefs related to work,

Study	Health status/ n	Age in years	Pain level scale: mean	Disease duration	Pain-related threat beliefs scale: mean (SD)	Disability scale: mean (SD)	Device/variable	Task/condition	Result
Pranata et al. (2018)	CLBP/43 Control/29	CLBP with high disability:46.7 CLBP with low disability:42.3 Control:37.8	NPRS: CLBP with high disability: 4.5 (1.9) CLBP with low disability: 3.0 (1.6)	>3 months	-	ODI: CLBP with high disability: 34.4 (10.9) CLBP with low disability: 13.2 (4.9)	Motion analyzer / ROM, Vel	Lifting with maximal lumbar flexion	No significant correlation
La Touche et al. (2018)	CLBP/49 Control/31	CLBP/45.1 Control/40.2	-	>6 months	TSK: 27.61 (6.18) PCS: 20.23 (10.14) CPSS: 138.4 (28.77)	RDQ: 8.71 (3.38)	Inclinometer/ ROM	Lumbar flexion	Significant moderate correlation
La Touche et al. (2019)	NCLBP/60	NCLBP with high self-efficacy: 38.17 NCLBP with low self-efficacy: 36.53	VAS: NCLBP with high self-efficacy: 3.95 NCLBP with low self-efficacy: 4.41	>6 months	TSK: NCLBP with high self-efficacy: 22.23 (6.92) NCLBP with low self-efficacy: 29.43 (5.22) PCS: NCLBP with high self-efficacy: 8.07 (5.66) NCLBP with low self-efficacy: 17.50 (7.95) FABQ: NCLBP with high self-efficacy: 20.13 (10.52) NCLBP with low self-efficacy: 32.50 (14.21) CPSS: NCLBP with high self-efficacy: 174.77 (6.53) NCLBP with low self-efficacy:138.53 (14.91)	RDQ: NCLBP with high self-efficacy: 4.57 (1.61) NCLBP with low self-efficacy: 5.9 (1.68)	Inclinometer /ROM	Lumbar range of motion,	Significant moderate correlation

LBP: low back pain, LOS: limit of stability, MODI: modified Oswestry disability questionnaire, MPQ: McGill pain questionnaire, MVAS: million visual analogue scale pain disability index, mVel: mean velocity, NCLBP: nonspecific chronic low back pain, NPRS: numeric pain rating scale, NR: not reported, ODI: Oswestry disability index, PDI: pain disability index, ROM: range of motion, RDQ: Rolland-Morris disability questionnaire, TSK: Tampa scale for kinesiophobia, VAS: visual analogue scale, Vel: velocity, WDI :Waddell disability index.

Table 4. Details of studies investigating the effects of pain-related threat beliefs and disability on postural sway

Study	Health status/n	Age in years	Pain level scale: mean	Disease duration	Pain-related threat beliefs scale: mean (SD)	Disability scale: mean (SD)	Device/variable	Task/condition	Result
Maribo et al. (2012)	CLBP/96	44.9	VAS: 4.01	> 8 weeks	FABQ- PA: 10.9 (5.3)	RDQ: 10.5 (5.3) SF-36 physical functioning: 72.2 (19.7)	Force plate/ COP, mVel, AP displ, mVel RR	Static Standing/ EO, EC	Significant poor correlation between disability and postural sway.
Champagne et al. (2012)	CLBP/ 15 Control/ 15	CLBP:68.9 Control: 69.4	QNPS: 2	○ 6 months	TSK: CLBP: 43.8 (5.9) Control: 33.4 (9.5)	ODI: CLBP: 15.6 (range:13.3–24.4) Control: 0 (0)	Force plate/ COP Vel, frequency	Static Standing/ EO	No correlation
Brech et al (2012)	CLBP/10	46.2	VAS:4.9		-	ODI:14.5(7.1)	Force plate/ COP Vel, AP and ML displacement	Static standing/ EO, EC Firm and foam	Significant moderate correlation with disability.
Davis et al. (2013)	CLBP/235	32	NPRS:3	> 3 weeks	FABQ-PA: 14 (range 0-24) FABQ-W: 15 (range 0-40) TSK: 33 (range 18-63)	MODI: CLBP with high disability> 20 CLBP with low disability<20	Computerized posturography / LOS reaction time, LOS Vel, LOS maximal excursion, LOS directional control	Static and dynamic standing	Significant poor correlation between disability and LOS Vel.
Mazaheri et al. (2014)	Current-NCLBP/20 Recent-NCLBP/20 Control/20	Current-NCLBP:33.5 Recent-NCLBP:35.3 Control:34.3	VAS: Current-NCLBP:5.09 Recent-NCLBP:1.15	-Current-LBP: > 6 weeks -Recent- LBP: > 6 weeks during the past year	TSK: Current-NCLBP: 43.6 (7.7) Recent- NCLBP: 41 (6.7) PCS: Current-NCLBP: 23.4 (11.9) Recent- NCLBP: 16.8(11.9)	ODI: Current- NCLBP: 16.1 (8.3) Recent- NCLBP: 9.5 (5)	Force plate/ SD in AP and ML direction, sway speed, MPF in AP and ML direction	Standing/ EC, EO, narrow and wide BOS, with and without cognitive load	No correlation

AP: antero-posterior, BOS: base of support, CLBP: chronic low back pain, COP: center of pressure, EC: eyes-closed; EO: eyes-open, FABQ-PA: fear avoidance beliefs related to physical activity, LBP: low back pain, LOS: limit of stability AP disp: mean anterior–posterior displacement, ML: mediolateral, MPF: mean power frequency, mVel: mean velocity, mVel RR: mean velocity of Romberg ratio, NCLBP: nonspecific chronic low back pain, NPRS: numeric pain rating scale, NR: not reported, ODI: Oswestry disability index, PASS: Pain Anxiety Symptoms Scale, PCS: pain catastrophizing scale, QNPS: quadruple numerical pain scale, RDQ: Rolland-Morris disability questionnaire, SD: standard deviation, SF-36: short form 36, TSK: Tampa Scale for Kinesiophobia, VAS: visual analogue scale, Vel: velocity

Table 4. continued.

AP: antero-posterior, BOS: base of support, CLBP: chronic low back pain, COP: center of pressure, EC: eyes-closed; EO: eyes-open, FABQ-PA: fear avoidance beliefs related to

Study	Health status/ n	Age in years	Pain level scale: mean	Disease duration	Pain-related threat beliefs scale: mean (SD)	Disability scale: mean (SD)	Device/variable	Task/condition	Result
Sung et al. (2015)	Acute to subacute LBP/ 33 Control/33	LBP: 32 Control: 34	NPRS: 4.2	<3 months	FABQ- PA: 12 (6.4)	ODI: 23.9 (8.9)	Force plate/area, mVel	Static Sitting /EO.EC	No correlation
Shanbehzadeh et al. (2018)	CLBP/ 38 Control/ 20	CLBP: 28.61 Control: 28.32	VAS: -High Pain-related threat beliefs subjects: 1.75 -Low Pain-related threat beliefs subjects: 1.52	persistent pain > 6 months or three self-reported recurrent pain episodes during the past year	PASS: CLBP with high Pain-related threat beliefs: 44.21(9.5) CLBP with low Pain-related threat beliefs :19 (9.1)	ODI: CLBP with high Pain-related anxiety: 18.9 (9.84) CLBP with low Pain-related anxiety: 17.11 (8.76)	Force plate/ mVel, area, mean AP and ML displacement	Static bilateral Standing/EO, EC, with and without vibration, with and without cognitive task	Significant moderate correlation.
Ozcan Kahraman et al. (2018)	NCLBP /51	Males: 38 Females:40	VAS: Males: 7.0 Females: 8.0	>3 months	TSK: Males: 42.0 (range 39.0 – 44.0) Females: 43.0 (range 37.0 – 46.25)	ODI: Males: 20.0 (15.50 – 27.0) Females: 28.0 (17.90 – 45.0)	NeuroCom Balance Master System/ mVel, LOS	Static and dynamic unilateral and bilateral standing/ EO, EC, firm, soft	Significant moderated correlation between Pain-related threat beliefs s with dynamic postural sway. No correlation with disability.

physical activity, LBP: low back pain, LOS: limit of stability AP disp: mean anterior–posterior displacement, ML: mediolateral, MPF: mean power frequency, mVel: mean velocity, mVel RR: mean velocity of Romberg ratio, NCLBP: nonspecific chronic low back pain, NPRS: numeric pain rating scale, NR: not reported, ODI: Oswestry disability index, PASS: Pain Anxiety Symptoms Scale, PCS: pain catastrophizing scale, QNPS: quadruple numerical pain scale, RDQ: Rolland-Morris disability questionnaire, SD: standard deviation, SF-36: short form 36, TSK: Tampa Scale for Kinesiophobia, VAS: visual analogue scale, Vel: velocity