FLEX CEUs

Low Back Pain: The Role of Fear

The Back Belief Questionnaire is efficient to assess false beliefs and related fear in low back pain populations: A transcultural adaptation and validation study

Background

According to the fear avoidance model, beliefs and thoughts can modify the outcome of patient with low back pain. The Back Belief Questionnaire (BBQ)–a 14 items scale–assesses these consequences of low back pain.

Objective

To test the psychometric properties of the French version of the BBQ.

Methods

The BBQ was translated using the forward–backward translation process. Throughout three repeated evaluation time points (D1, D7 and D30), various aspects of validity were analysed: acceptability, quality of items, unidimentionality, internal consistency, temporal stability (between D1 and D7), responsiveness (between D7 and D30), and construct validity comparing it to other validated scales.

Results

One hundred and thirty-one patients were enrolled and 128 were analyzed. The acceptability and the quality of the items were excellent. The scale was unidimensional and reliable (internal consistency: Cronbach's α = 0.8). The responsiveness was moderate but in line with other scores. The BBQ was, as expected, convergent with day-to-day activities and fear avoidance (FABQ and Tampa), disability (Quebec and Dallas scores), or anxiety and depression (HAD); and not correlated with pain. Best correlations were found with Tampa and FABQ. The temporal stability (test-retest reliability) was poor. However, similar changes were observed in near conceptual score (FABQ), which confirmed that clinical status may have not been stable and suggesting sensitivity to early changes for BBQ.

Conclusions

The BBQ showed good psychometric properties to assess false beliefs and related fear in French or English LBP populations and can be used either for evaluation in international trials or as a part of self-care training.

Introduction

According to the bio-psychosocial model, the course of chronic low back pain (CLBP) is widely influenced by emotional, cognitive and behavioral factors [1]. It is well known that cortical processes are involved in the integration of multidimensional aspects of pain. This highlights the shift from mechanical to functional response and leads to cognitive and behavioural adaptation when pain persists. Therefore, patients may adopt individual strategies depending on expectations, fears, and beliefs [2]. There is increasing evidence that beliefs as well as thoughts are widely altered in LBP patients [3] but also in physicians [4]. It is also clear that beliefs can change the way that patients struggle for recovery and autonomy [5].

Symonds *et al*. have developed a specific self-reported questionnaire–the Back Beliefs Questionnaire (BBQ)–designed to explore beliefs and thoughts related to low back pain [6]. Unlike the Fear Avoidance Beliefs Questionnaire (FABQ) score, which explores beliefs related to consequences of LBP on physical and work activities avoidance, the objective of the BBQ is to determine the presence of various inevitable consequences of LBP in patient's future among 14 determinants. The first validation of the English version only comprised reliability and consistency in individuals and workers and showed that BBQ was able to distinguish workers with false beliefs associated with longer work absenteeism [6]. The BBQ seems to be used in practice, usually in self-care and multidisciplinary programs probably as far as an evaluation (seeking false beliefs) or educational tool (treating false beliefs) [7]. However, this questionnaire has not been tested in non-worker LBP patients and likely needed more extensive validation process.

The aim of this work was to provide a French transcultural validated version of the BBQ. The study was divided into two steps: i) translation and cultural adaption of the BBQ and ii) validation of the French version in terms of acceptability, quality of the items, unidimensionality, internal consistency, temporal stability, responsiveness, and construct validity.

Method

The BBQ

Pain-related fear is known to affect daily activities and the development of disability as patients elaborate unsuitable representations of danger, either painful, crippling or destructive and the usefulness of the majority of treatments. Therefore, the items have been designed in order to explore the degree of agreement of patients about developing various inevitable status related to LBP in the future. The questionnaire consists in a 14-item beliefs score. Nine items are used for the score (Q1, Q2, Q3, Q6, Q8, Q10, Q12, Q13 and Q14) and five are used as distractors (Q4, Q5, Q7, Q9 and Q11). The level of each belief ranks from total disagreement to total agreement on a Likert 5-level scale. The score obtained for each item is reversed (e.g. 5 means 1 and 2 means 4) and nine items included in the total score are added. For each item, the higher score means the worst future perceived (either illness perception or treatment effectiveness). For the entire BBQ, the higher the patient scores, the less he displays fear and false beliefs (as scores are reversed).

Translation

The BBQ was transculturally translated using the forward / backward procedure [8,9] Three French native bilingual physicians (AD, EC, AG) independently translated the questionnaire. They were asked to provide a global rather than word for word translation [10]. They reviewed each translation together for cultural adaptations and obtaining a consensus version. A backward translation into English was then proposed by a native English translator (CS) to check the meaning of each item.

Population

Patients were eligible if i) they were consulting for back pain condition lasting more than 3 months, ii) previous treatments (medications and/or physiotherapy) had been ineffective and iii) they had no previous history of surgery or multidisciplinary rehabilitation program or dedicated educational intervention. All patients signed an informed consent. The study was approved by the regional ethics committee (Comité de Protection des Personnes Sud Méditerranée III, 2011.06.05), recorded by French authorities (RCB ID n° 2011-A00270-41 delivered by AFSSAPS), and declared on Clinical trials (NCT01389999).

Study design

To validate the French version of the BBQ, this questionnaire was included in a multidimensional evaluation of CLBP integrated in rehabilitation programs provided by two tertiary care University Hospitals. The questionnaires were filled out on the day of enrolment (D1), on the first day of the rehabilitation program (D7) and one month after the end of the rehabilitation program (D30). No treatment or intervention was scheduled between D1 and D7. The D30 session aimed at controlling the beliefs' changes if any.

Objective of the study: Validation of the translated BBQ

The validation process consisted in the assessment of the i) acceptability of each item and of the global questionnaire; ii) quality (absence of saturation, ceiling or floor effect, and redundancy) of each item and of the global questionnaire; iii) unidimensionality of scale; iv) internal consistency; v) temporal stability using a test-retest reliability method between D1 and D7 in strictly the same conditions; vi) responsiveness between D7 and D30; and vii) construct validity using correlations with other validated questionnaires exploring different dimensions to assess convergence and divergence.

The other validated questionnaires used were: the FABQ for fear and avoidance [11,12], the Quebec scale for disability [13], HADs for anxiety and depression [14], the Tampa for kinesiophobia [15], Visual analogue scale (VAS) for the pain, and the Dallas pain questionnaire for day-to-day activities [16]. At D1 only the BBQ, Tampa, Quebec and FABQ were recorded in order to control for changes in close concepts (fear and kinesiophobia), all questionnaires were administered at D7 and D30.

Statistical analysis

Acceptability was assessed by the number and the proportion of the overall and for each item absence of responses (coted "no"). Acceptable items have to provide a proportion of "no" responses lower than 5%, if the proportion is higher than 10% the item is disputable.

Quality of items was assessed by the absence of saturation for each of them: ceiling or floor effect and by the absence of redundancy between items evaluated by the nonparametric Spearman rank correlation coefficient (with its 95% confidence interval, CI 95%) [17]. Spearman correlations above 0.9, between 0.7 and 0.9, between 0.5 and 0.7, between 0.3 and 0.5 and below 0.3 were considered as excellent, good, moderate, poor, and negligible.

Unidimensionality of the scale was assessed using the Mokken Scale Procedure (MSP) [18]. The MSP aims at automatically partitioning the items into one or several sets by defining the dimensions of the scale and possibly a set of unscalable items using Loevinger H coefficients.

Internal consistency was estimated using the Cronbach's α coefficient (CI 95%). A value of the score over 0.7 was considered reliable. The step-by-step Cronbach-α backward procedure was used also to check the unidimensionality of the scale.

Temporal stability was assessed to control that the scale remained stable when clinical condition did not change. Test-retest reliability was assessed between D1 and D7. Stability of the global score was assessed using the intraclass correlation coefficient (ICC; CI 95%). ICC is considered as excellent over 0.9, acceptable over 0.8, weak over 0.6 and inexistent below. The stability of each item was assessed by the weighted kappa coefficient (K; CI 95%). K is excellent over 0.8, good over 0.6, medium over 0.4, poor over 0.2, bad over 0, inexistent below 0. The Bland & Altman graph method was used to evaluate the presence of a bias [19].

Responsiveness was assessed between D7 and D30 with the Cohen's adjusted Standardised Response Mean (SRMa) [20] and tested using the Wilcoxon paired test. SRMa > 0.8, > 0.5, > 0.2 and below are considered large, moderate, small and trivial, respectively.

Construct validity was assessed by searching convergence and divergence with other dimensions assessed by other scales. Following the convergent hypothesis, a low BBQ (low knowledge about LBP) was expected to match with high FABQ or TAMPA scores (high fear leading to movement and activities avoidance) and high Quebec or Dallas scores (high disability). On the other hand, in a divergent hypothesis, the BBQ would likely not be correlated with HAD (anxiety or depression) and VAS (pain). This validity was measured using the nonparametric Spearman rank correlation coefficient (CI 95%).

Supplementary analyses: A parametric item response theory (IRT) model was used to characterise the BBQ scale properties such as difficulty and discrimination of each item [21]. All the analyses were performed using SAS software version 9.4 (SAS Institute Inc., Cary, NC).

Results

Translation

The French version of the BBQ (S1 Appendix) was not different in structure from the original version. No cultural adaptation was necessary and only minor adaptations were made. The final version was sent to one of the authors of the original BBQ (A.K. Burton) who gave a feedback with the translated version and confirmed that the translated version and the English version explored the same dimension.

Population

Overall 131 patients were enrolled in the study: 128 patients at D1 (Centre 1, 105; Centre 2, 23), 121 at D7 (103/18) and 101 at D30 (96/5) (Fig 1). Mean age at inclusion was 43.6 ± 10.1

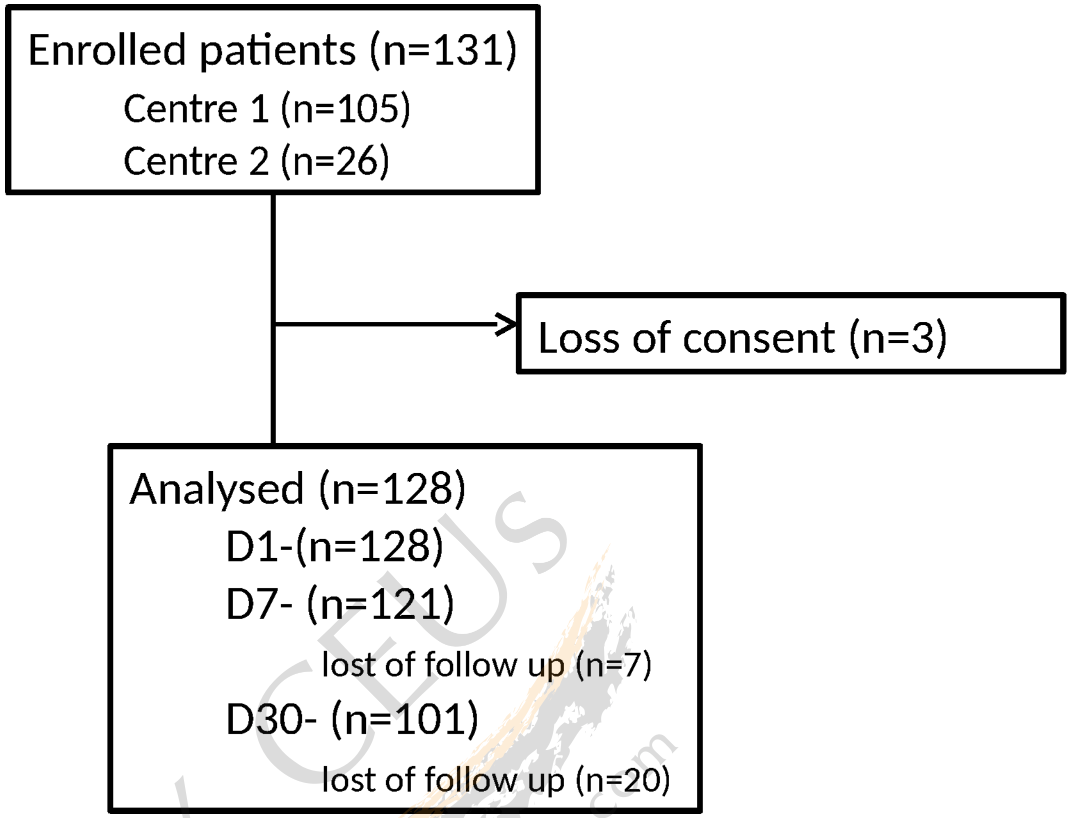


Fig 1. Flow chart.

(range 23–68), 62 (48%) were female, median duration of LBP was 49 months (range 3–400; inter-quartile range 18–133). LBP population' characteristics are detailed in Table 1.

Table 1. LBP characteristics of the study population at the reference visit (D1).

	Missing values	Median	Range	IQR
Pain (0–100)	15	44	0–100	35–52
FABQ (0–66)	1	39	4–66	26–51.5
○ Physical activity (0–24)	0	15	0–24	11–18
○ Work (0–42)	1	26.5	0–42	13.5–35.5
Tampa (0–68)	5	45	21–66	38–49
Quebec (0–100)	1	36	3–82	23.5–52
Dallas (%)				
○ Daily activities	0	55.2	22.2–84.6	46.2–64.8
○ Work-Leisure activities	1	54.5	7–94	40–67
○ Anxiety-Depression	0	40	0–100	25–60
○ Social interest	0	34	0–87	14–54
BBQ (0–45)	0	24	10–41	19–28
HAD				
○ Anxiety (0–21)	2	10	3–21	7–13
○ Depression (0–21)	2	7	1–18	4–10

Testing the questionnaire

Regarding acceptability for the BBQ tests, most of the BBQ collected were completed and only 0.43% of all items were not filled (21/4858). A moderate ceiling effect was found for the items Q2 (32%), Q3 (36%) and Q6 (54%) as most of patients scored highest level and a floor effect for the item Q8 (60%) as most of patients did not believed that they would be, one day, forced to use a wheelchair because of their back pain. Nor floor neither ceiling effect was detected for the global score. Correlations between items were very low or absent (Spearman < 0.5) showing no redundancy between items.

One unique dimension was defined by the MSP confirming the unidimentionality of the BBQ scale. However, two items (Q1 and Q8) did not satisfy the cut-offs for the Loevinger H coefficient and were not selected by the MSP in the unique dimension of the scale.

Global Cronbach α coefficient was 0.8 (0.7–0.8) and above the 0.7 cut-off for reliable internal consistency. The step-by-step Cronbach α backward procedure confirmed the general agreement between items measuring the same construct (Fig 2). The graphical representation

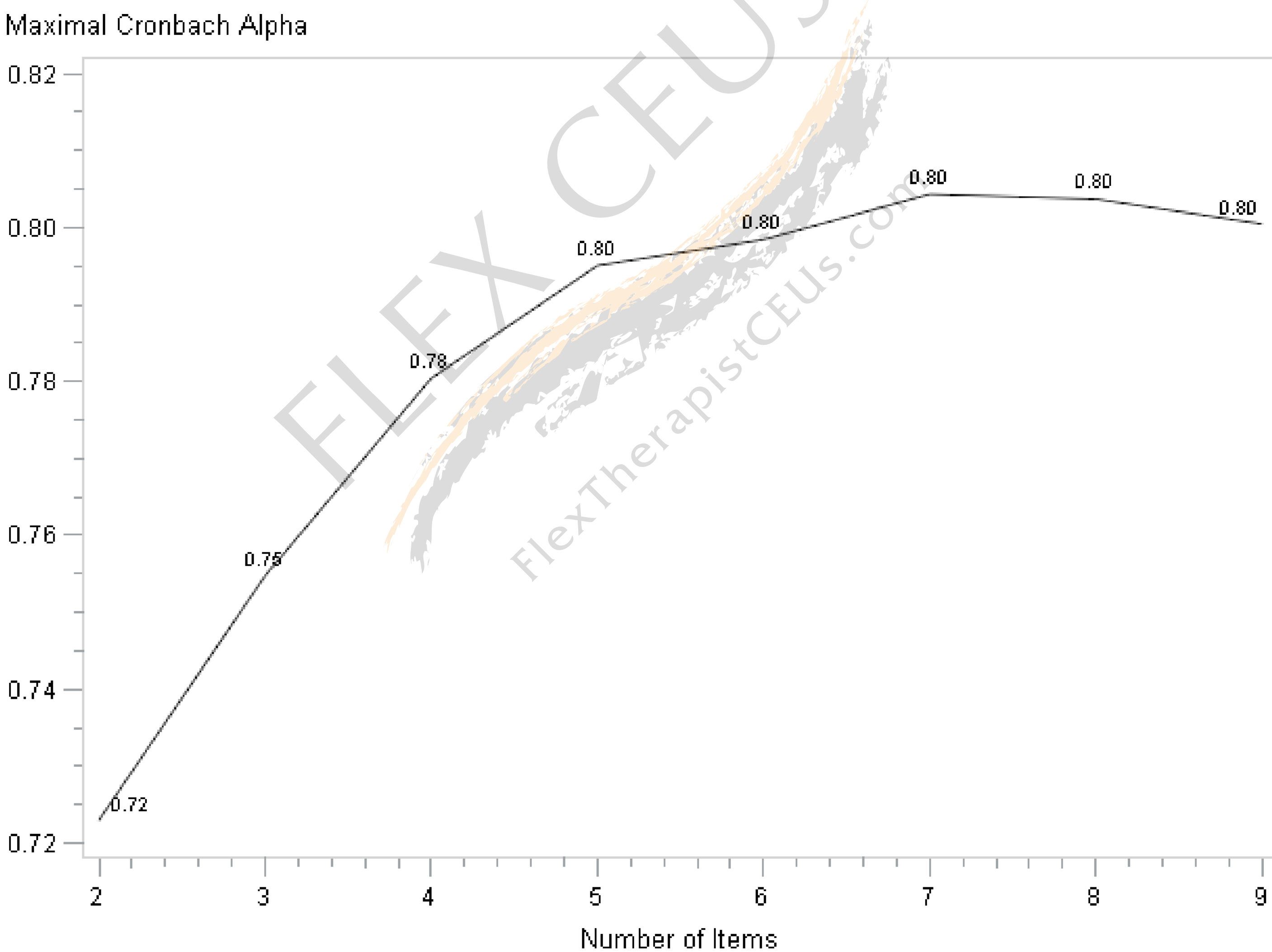


Fig 2. Step-by-step Cronbach α backward procedure according the number of items. The items were successively removed according the following order: Q8, Q1, Q13, Q12, Q3, Q10, Q2 (remaining Q6 and Q14).

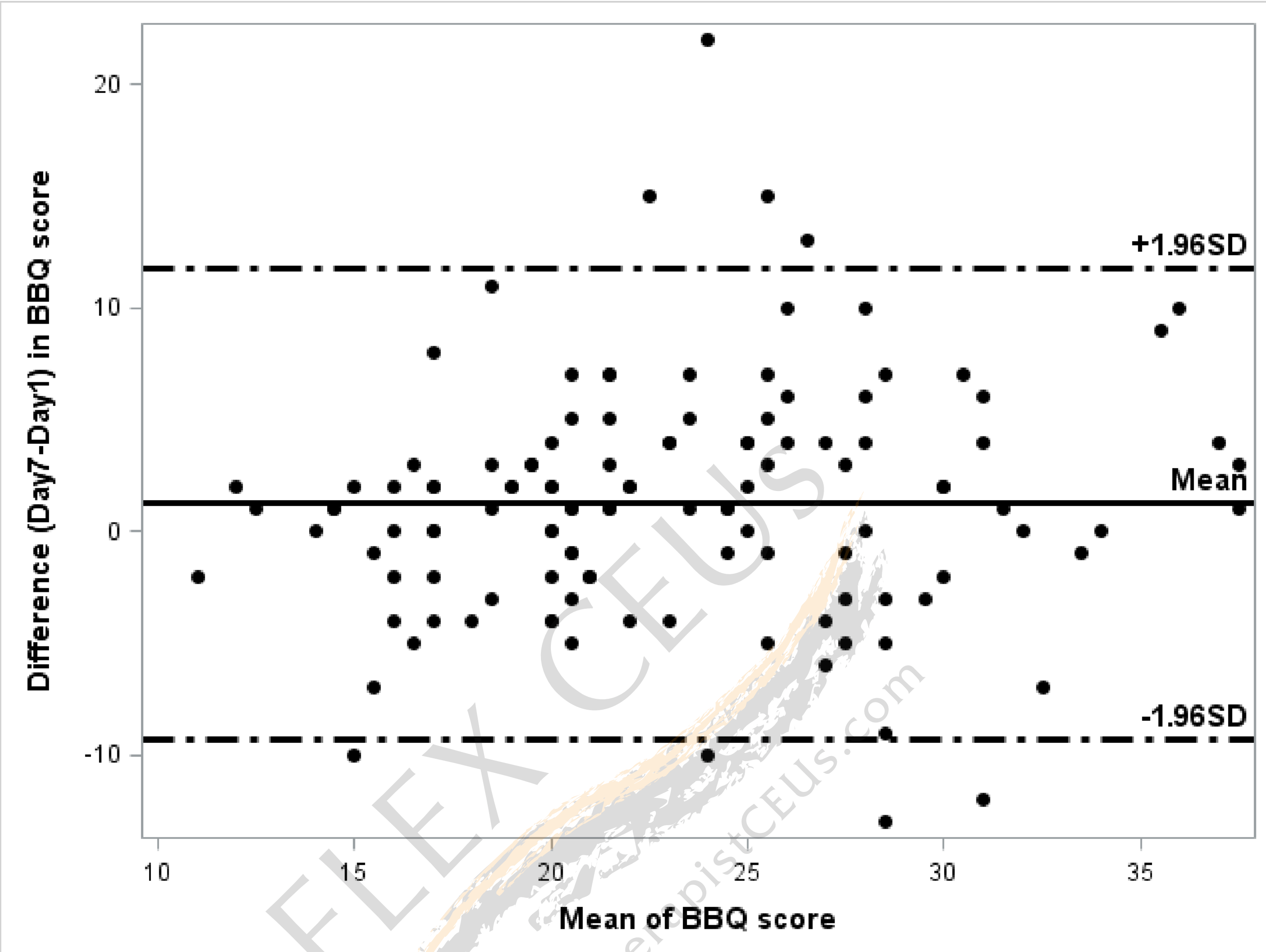


Fig 3. Bland & Altman method representation of a bias in the test-retest reliability method to assess temporal stability between D1 and D7. A bias between the mean differences can be detected. Here the score calculated at the second visit is +1.24 higher.

obtained at the end of the Cronbach α procedure is monotone increasing, which reflects a good reliability of all items. The BBQ does not have any items causing a decrease of the curve. This confirms the results from the factor analysis for unidimensionality.

Temporal stability was low between measures performed at D1 and D7 with a 0.64 ICC (CI 95%; 0.52–0.73) for the global scale and a K varying from 0.24 (0.11–0.38) to 0.46 (0.35–0.57) for each item. The Bland & Altman graph (reported in Fig 3) shows the existence of a bias of +1.24 meaning an improvement of the beliefs already at D7. BBQ scores at D1 and D7 were 21 [18–27] (median, IQR) and 24 [19–28] respectively ($p = 0.01$). No difference was found between centre, gender and back pain duration between visits to explain this poor temporal stability. A change in FABQ between D1 and D7 was also found (44 [28–54] and 39 [26–51], respectively ($p = 0.03$)) whereas Tampa scores were not different ($p = 0.87$). Therefore, both BBQ and FABQ scale's score changed significantly for the same subset of patients.

The responsiveness to the BBQ was moderate and coherent with the other scores, as shown in Table 2.

Table 2. Responsiveness of the BBQ compared to different scores before and after the rehabilitation procedure.

	n	Before rehabilitation Median [IQR]	After rehabilitation Median [IQR]	p	Cohen's adjusted SRM
FABQ total (/66)	96	39.0 [26.6–50.5]	28.0 [14.5–42.0]	<0.0001	0.81
Physical Activity (/24)		16.0 [12.0–19.0]	7.0 [2.0–13.0]	<0.0001	
Work (/42)		25.5 [13.0–35.5]	19.5 [8.5–34.0]	<0.0001	
Tampa (/68)	92	45.0 [38.5–50.0]	36.0 [30.0–43.0]	<0.0001	0.98
Quebec (/100)	98	34.0 [22.0–48.0]	20.5 [12.0–38.0]	<0.0001	0.94
BBQ (/45)	100	23.5 [18.5–28.0]	27 [22.5–32.5]	<0.0001	-0.7

(IQR: inter-quartile range)

The construct validity was estimated at D7 for all variables. Consistently with the divergent hypothesis, there was no correlation with pain (r = -0.15, p = 0.19). Regarding the convergent hypothesis, the BBQ was best correlated with the Tampa (r = -0.66, $p<0.001$) and the FABQ (r = -0.52, $p<0.001$). Correlations with disability scales were poor (Quebec, r = -0.31, $p<0.001$; Dallas, r = -0.24 to -0.43, $p<0.01$). Oppositely to the divergent hypothesis, the BBQ scale was correlated, although weakly, with HADs depression (r = -0.42, $p<0.001$) or anxiety (r = -0.28, p = 0.0017).

According to the parametric IRT model results, the most discriminative items of the scale were the items 14 and 6, and the less discriminative the items 1 and 8, which were indeed the less difficult items. The information curves obtained by the parametric IRT model are presented in Fig 4.

Discussion

Overall, this study shows that the French version of the BBQ has good psychometric properties and can be used for evaluation of thoughts, knowledge and beliefs in patients with LBP. The translation process required only vocabulary changes with a questionnaire easily comprehensible and well accepted by patients. This aspect of low back pain is very important to address since the fear avoidance model widely explains how false beliefs and wrong thoughts contribute to wrong outcome [22].

What the study adds

In addition to the extension of the BBQ use in French, this study brings additional knowledge. Indeed, although the construct validity, internal consistency or temporal stability have already been explored, characteristics such as quality of items and responsiveness have not been previously analysed. However, populations enrolled in previous studies were not necessarily involved in long term disability related to low back pain, usually screened for rehabilitation and education multidisciplinary programs. The population targeted in the present study gives a more accurate picture of LBP patients with severe disability related to beliefs.

Overall, the BBQ is well accepted (0.43% of no-responders) with no floor or ceiling effect detectable for the global score, neither redundancy between items (weak to very weak correlation between items, spearman < 0.5). This can explain the low rate of non-responders (14.3% for Bostick *et al.*) [23] or missing data (13.5% for Symonds *et al.*)6 described elsewhere. However, researchers should pay attention to items' ceiling effect (Q2, Q3 and Q6), resulting in a poor discriminating ability to detect some specific LBP patients' beliefs as most of them consider that back pain will mean pain for the rest of their life (Q3), will limit daily life activities (Q2) or work to some individual extend (Q6). Conversely, Q8 demonstrated a floor effect as

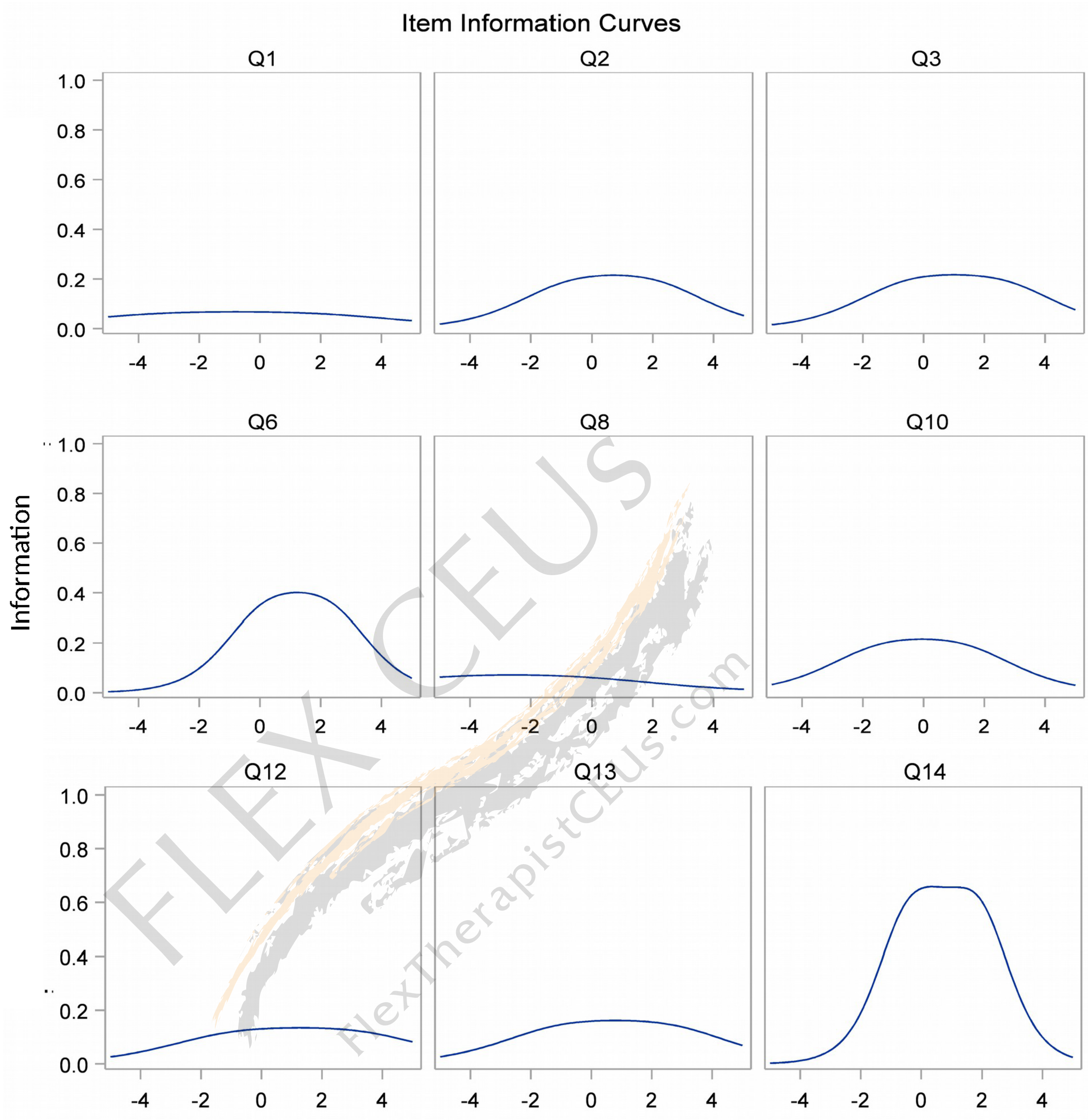


Fig 4. Item information curves of the nine items used for scoring the BBQ scale obtained by the parametric IRT model. Items 1, 8, 12 and 13 have a low power of information over the entire scale. These items contributed very little to the ranking of individuals. Conversely, the strongest informations power were observed for items 6 and 14. The minimal anonymized data set of the present study is available in S2 Appendix.

most patients do not belief that back pain will lead to severe impairment. However, this thought, usually reported in educational assessment, is probably used by patients to test physicians' opinion but cannot objectively be considered as a false belief. As a consequence, the interpretation of such item factor components must be careful.

The correlation between the nine items was good (Cronbach's coefficient = 0.8; Fig 2) as found by others [6,23] confirming the good internal consistency. Each item seems to evaluate the same construct with α coefficient always over 0.7 and still stable after each deletion without any significant redundancy between items.

Comparison to other scores

The concept that fear and beliefs lead to movement and activities avoidance, disability, and therefore inevitable consequences of low back pain, according to the fear avoidance model [24] was believable. As expected, the BBQ was convergent with others scales which have close concepts such as Tampa for kinesiophobia and FABQ for fear avoidance of work and physical activity (spearman coefficient >0.5; $p<0.001$). This association was higher than regarding functional scales: for example, the relationship with the Quebec scale was weaker but still significant (spearman coefficient <0.5; $p<0.001$).

Unexpectedly, disability and depression, explored with Dallas and HAD scales were convergent with BBQ although weakly (spearman coefficient <0.5; $p<0.01$). However, the link between HAD (anxiety part) and Tampa scale [25] or FABQ and HAD [12,26] can explain such a relation.

Therefore, the BBQ gives clinicians some new information that are probably not provided elsewhere considering the weak or inexistent correlations observed with other scores.

In a previous study, Bostick *et al*. [23] have tested the relationship between beliefs and history of low back pain. However, the results suggested that beliefs were not exclusively linked to pain. This is confirmed by the divergence of BBQ with pain evaluation. Fear can lead to pain (Montaigne; "He who fears shall suffer, already suffers what he fears") but does not explain or encompass pain. Finally, the best correlations observed with Tampa and FABQ were expected since fear of movement and avoidance are conceptually close [26–28]. Therefore, in a non-worker LBP population, the BBQ can be easily used and interpreted in this frame.

Finally, for the first time the responsiveness of the BBQ after an educational and rehabilitation program has been tested. In most cases, beliefs improve after multidisciplinary interventions and accordingly the BBQ score increases after one week of educational intervention (4.5 points increasing; $p<0.0001$). The BBQ score can therefore be used as an objective tool of education assessment in CLBP. Furthermore, associated with a rehabilitation intervention, the BBQ was able to detect changes accordingly with other scales testing avoidance of movement, return to work, kinesophobia or and functional abilities as reported here (Table 2).

Limitations

Temporal reliability tests have shown that test-retest reliability between D1 and D7 was either weak or poor according to definition. This can be unexpected since no intervention was scheduled during this period. Two hypotheses may explain this result. First, it could be suspected that the BBQ is not stable with time and probably variable whereas the clinical status is stable; however, this hypothesis requires confirmation that no clinical change has occurred. Second, it can be suspected that the patient educational assessment proposed at inclusion (D1) has already modified the related beliefs. The changes observed on the FABQ scores between D1 and D7 pleads this reason. Moreover, FABQ have demonstrated a good temporal stability [26, 27]. Since educational interventions modify beliefs in LBP population [29–31], changes in the BBQ and another score would rather support the sensitivity to change of BBQ. In this study, patients, were enrolled because of chronic LBP and were evaluated the same day of the inclusion. It is possible therefore that the educational questioning provided the first day would have led to changes in back pain thoughts because of the discussions with the team and/or exchanges between participants. This hypothesis however, needs to be confirmed by studies with no educational assessment.

Finally, data on the professional status of the patients included was not specified so we are not able to extrapolate our results to the general LBP population.

Perspectives

The use of the BBQ score for evaluation of inevitable consequences of beliefs related to LBP and educational assessment seems of interest. However, the usefulness of the whole set of items could be questioned. Bostick and colleagues [23] have already underlined the little change in the overall score whether Q1 remained or not (correlation still very high and reliability unchanged). Similarly, in the present study, the interest of Q1 as well as Q8 were disputable. Indeed, these two items were not selected in the MSP, they demonstrated the weakest input for internal consistency and they were the less discriminative item in the IRT model. Therefore, it could be interesting to test the validity of the BBQ using only "loading items" for scoring and propose another form of the questionnaire. Nevertheless, the distractors are interesting in an educational perspective. Indeed, the BBQ is typically oriented toward emotions, thoughts and beliefs assessment and can be easily used as educational support. Each item explores most of the questions asked by LBP patients (e.g. "*back trouble will stop you from working*" or *"means you end up in a wheelchair")* and can open a face-to-face discussion on individual worst beliefs. In this perspective, the BBQ may enhance their ability to catch unpleasant but still vague related thoughts for a better understanding and management [7,24].

Conclusion

The BBQ, now available in French language, showed good psychometric properties to assess false beliefs and related fear in French LBP populations. These results suggest that the questionnaire can be used either for evaluation in international trials or as a part of self-care training.

Fear of Movement Is Related to Trunk Stiffness in Low Back Pain

Abstract

Background: Psychological features have been related to trunk muscle activation patterns in low back pain (LBP). We hypothesised higher pain-related fear would relate to changes in trunk mechanical properties, such as higher trunk stiffness.

Objectives: To evaluate the relationship between trunk mechanical properties and psychological features in people with recurrent LBP.

Methods: The relationship between pain-related fear (Tampa Scale for Kinesiophobia, TSK; Photograph Series of Daily Activities, PHODA-SeV; Fear Avoidance Beliefs Questionnaire, FABQ; Pain Catastrophizing Scale, PCS) and trunk mechanical properties (estimated from the response of the trunk to a sudden sagittal plane forwards or backwards perturbation by unpredictable release of a load) was explored in a case-controlled study of 14 LBP participants. Regression analysis (r^2) tested the linear relationships between pain-related fear and trunk mechanical properties (trunk stiffness and damping). Mechanical properties were also compared with t-tests between groups based on stratification according to high/low scores based on median values for each psychological measure.

Results: Fear of movement (TSK) was positively associated with trunk stiffness (but not damping) in response to a forward perturbation ($r^2 = 0.33$, $P = 0.03$), but not backward perturbation ($r^2 = 0.22$, $P = 0.09$). Other pain-related fear constructs (PHODA-SeV, FABQ, PCS) were not associated with trunk stiffness or damping. Trunk stiffness was greater for individuals with high kinesiophobia (TSK) for forward ($P = 0.03$) perturbations, and greater with forward perturbation for those with high fear avoidance scores (FABQ-W, $P = 0.01$).

Conclusions: Fear of movement is positively (but weakly) associated with trunk stiffness. This provides preliminary support an interaction between biological and psychological features of LBP, suggesting this condition may be best understood if these domains are not considered in isolation.

Introduction

People with low back pain (LBP) have changes in muscle activation [1,2], trunk mechanical properties [3,4]) and fear of pain [5,6]. Although biological and psychological domains are often discussed in isolation, they are likely interdependent. Consistent with this view, studies have shown that adaptation in muscle activation depends on attitudes about pain [7], and compromise of the expected relaxation of the lumbar muscles at trunk flexion end range in people with LBP correlates with high fear avoidance behaviour [8]. Although it is assumed changes in trunk muscle activation relates to differences in trunk mechanical properties, the association between variation in psychological presentation and trunk mechanical behaviour has not been tested.

A relationship between psychological and mechanical features would support contemporary neurophysiology and psychology pain models, for example, the prediction of pain/threat of injury causes the body to protect the painful part in an effort to reduce pain [9], the fear-avoidance model [10,11], and the diathesis-stress pain theory [12] (i.e., behaviours which provide short-term relief can have detrimental long-term effects if the behaviour remains unchanged [13]). We considered simultaneous investigation of biological and psychological systems could help to better understand this relationship between mechanical and behavioural domains.

Investigation of how biological and psychological features interact is of relevance because they both have the potential to influence the presentation and management of LBP. Motor control (i.e., trunk stiffness, relative tissue flexibility, preferred movement strategies) and psychological factors (i.e., emotions, cognitions, behaviours) are both likely to influence motor output and alter trunk mechanical behaviour. Depending upon the robustness of 'motor' and 'psychological' systems, it is probable the relationship is bi-directional in nature. Optimal trunk mechanical performance will vary depending upon the required task, and if a person with LBP cannot efficiently alter their mechanical response, it may have negative long-term biopsychosocial consequences (i.e., increased trunk load, reduced movement variability, reinforcement of maladaptive pain behaviour).

Several psychological features have been explored in relation to LBP, most notably dimensions related to the fear-avoidance model [14]. The three aspects of this model are fear of movement/re-injury, pain catastrophizing [15], and avoidance behaviour, all of which could relate to changes in trunk motor control. Questionnaires to assess these components have been developed [16–19]. There has also been a focus on distress [20,21]. It remains unknown which psychological features, if any, are related to trunk mechanical properties. In this study we aimed to test the hypothesis that higher kinesiophobia relates to greater protection of the spine (increased trunk stiffness) by exploring the relationship between trunk mechanical properties and other aspects of the fear-avoidance model (pain catastrophizing thoughts, avoidance behaviour) as well as a component of the distress model (depression).

Methods

Participants

Nineteen participants with LBP (6 male, 13 female; mean body mass index (BMI) 23.6 (SD 3.8); mean age 43 (range 26–65 years)) were recruited with the objective to include those with both high and low fear of pain. Participants were included if they scored at least a 10 out of 100 on the Quebec Back Pain Disability Scale (QBPDS), reported a pain intensity of at least 1/10 at the time of participant screening (Numeric Pain Rating Scale, NPRS), and a BMI of ≤31. Exclusion criteria were a history of cancer, unexplained weight loss >4.5 kg in the past 6 months, neurologic disease, severe spinal structural deformity (e.g., >8 mm rib hump), loss of bowel or bladder control, major changes in walking balance or strength, numbness or altered sensation in the groin region, respiratory disease, hip or knee surgery or currently had a hip or knee injury, use of a walking aide, numbness in their lower extremities, or pregnancy. Participants were recruited via university and city newspaper advertisements. The Institutional Medical Ethics Committee at the University of Queensland approved the study and participants provided written informed consent.

Procedure

Psychological dimensions. Participants completed questionnaires to evaluate the psychological features of their LBP. These were: Tampa Scale for Kinesiophobia (TSK), Photograph series of Daily Activities-Short electronic Version (PHODA-SeV), Fear Avoidance Beliefs Questionnaire (FABQ), Center for Epidemiological Studies-Depression Questionnaire (CES-D), Pain Catastrophizing Scale (PCS), Numeric Pain Rating Scale (NPRS), and Quebec Back Pain Disability Questionnaire (QBPDQ). .

The TSK [17] is a 17-item measurement of fear of movement/(re) injury (1 'Strongly disagree' to 4 'Strongly agree') and has good reliability and validity [5]. The PHODA-SeV [19] is a valid and reliable measure of perceived harmfulness of physical activity (0 'Not harmful at all' to 100 'Extremely harmful') in patients with chronic LBP [19]. To gather a better comparison of the basic movement categories portrayed in the PHODA-SeV and the experimental tasks that would be performed by the participants, an additional component was added to the PHODA-SeV that involved a photograph and explanation of the experimental trunk perturbation task (see below) (Photograph of Experimental Task [PHOET]) (Figure 1). Participants rated their perceived harmfulness of participating in this task according to the same 'harmfulness thermometer' used in the PHODA-SeV before and after completing the test.

The PCS [18] is a 13-item questionnaire that reliably measures thoughts and feelings related to pain which suggest catastrophic thinking [22]. The FABQ [16] measure avoidant behaviour with 16 items that measure the agreement of statements related to Physical Activity (FABQ-PA) and Work (FABQ-W) affecting the participant's LBP, and is a valid and reliable measure of fear-avoidance constructs for 'chronic' LBP patients [22].

The CES-D contains 20 items related to how often the person has felt depressed during the last week. It has high sensitivity (81.8%) and specificity (72.7%), and good predictive validity among 'chronic' pain patients for measurement of symptoms of depression [23]. The QBPDS [24] is a 20-item questionnaire related to how back pain affects a person's daily life (0 'Not difficult at all' to 5 'Unable to do'). The NPRS [25] (0 'No Pain' to 10 'Worst imaginable pain') was administered at the time of recruitment, before the experimental task, and immediately following the experimental task. Measures of pain (NPRS) and the PHOET were preformed at the start of the testing session and after completion of mechanical testing.

Mechanical dimensions. Mechanical properties of the trunk were evaluated from the response of the trunk to a sudden perturbation [3] (Figure 1). Participants sat in a semi-seated position with the pelvis stabilized by a belt and low-level backrest. They were instructed to sit in their normal preferred posture. A chest harness was placed over the participant's shoulders and adjusted so that the attached cables were approximately at the trunk's center of mass (T9). Cables were attached to equal weights (7.5% body weight) by electromagnets and passed over low-friction pulleys. A marker was placed on the cable to serve as a guide to ensure consistent posture between trials. Because front and back loads were equal, minimal muscle activity was required to hold the trunk upright. A load was randomly released from the front (x20) or back

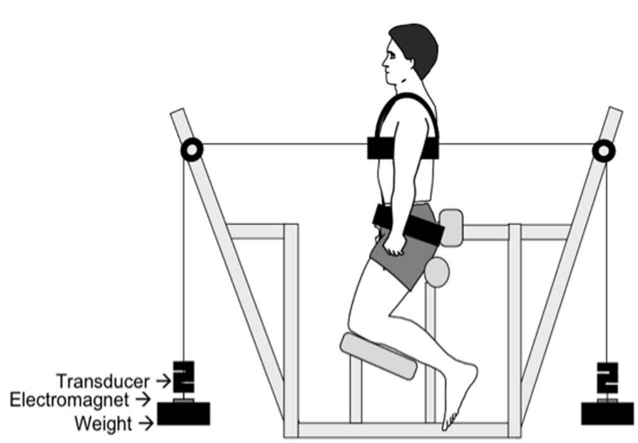


Figure 1. Experimental set-up. Participants sat in a semi-seated, upright posture with the pelvis fixated by a belt. The load was released from one side of the trunk by release of an electromagnet.

(x20) by deactivation of one electromagnet. Participants were instructed to return to their starting position after each perturbation. The dropped weight was re-attached, and successive drops followed every ~5 s until completion of the trial (~15 min).

Transducers (Futek Advanced Sensor Technology, Inc., Irvine, CA, USA) between the weights and trunk measured force. Force data were sampled at 200 Hz using a Power 1401 data acquisition system and Signal software (Cambridge Electronic Design, Cambridge, England). Data were exported and analyzed using Matlab (Mathworks, Natic, MA, USA).

Data Analysis

Trunk 'stiffness' is the body's ability to resist displacement and is the sum of passive (osseoligamentous system) and active (neuromuscular system) properties [26]. Trunk 'damping' is the body's ability to resist velocity. Stiffness and damping were estimated using a second order linear model (Equation 1) based on the applied force and resultant trunk kinematics, from the time of weight release until maximum trunk displacement.

$$F = m\ddot{x} + B\dot{x} + Kx \qquad (1)$$

Where F is the resultant force vector on the trunk $\ddot{x}$,$\dot{x}$ and x are the acceleration, velocity, and position vectors of the trunk, respectively. F was calculated by subtracting back from front force. $\ddot{x}$ was calculated from the force transducer attached to the unreleased weight, and was numerically integrated to calculate $\dot{x}$ and x. As m(effective mass), B (effective damping), and K (effective stiffness) were assumed to be constant, the standard least squares procedure was used to solve the estimation. To increase the procedure's robustness, data for the second-order linear equation were numerically integrated twice [27]. Modeled data were checked for validity by fitting a regression line between the modeled and recorded displacement data. Data were excluded from the analysis if the correlation coefficient was less than 0.97. This was identified for data from 2 participants.

To ensure normal distribution, data were transformed if Shapiro-Wilk and Shapiro-Francia test for normality was significant ($P<0.05$). The appropriate data transformation (logarithm, square root or inverse) was based on the best normal data distribution tested with skewness and kurtosis test for normality. Regression analysis was performed to test the linear relationships between trunk mechanical properties (trunk stiffness and damping) to both forward and backward perturbations and psychological factors (questionnaire scores). As an additional exploratory analysis and to provide additional support for any relationships identified in the regression analysis, data were stratified into groups with low and high scores for each psychological measure (divided by median values). The approach of using the median value or other cut-off values to divide the population based on their response to questionnaires (i.e., TSK) have been used in previous studies to describe the data [28,29]. Mechanical variables were compared between groups with t-tests for independent samples. As data for this secondary analysis was performed in an exploratory manner for further interpretation of regression analyses, a Bonferroni correction was not used as this was considered too conservative in this hypothesis-driven context [30]. NPRS and PHOET were compared between pre- and post-test measures with t-tests for dependent measures. Significance was set at $P<0.05$. Data are presented as mean and standard deviation (SD) throughout, unless stated otherwise.

Results

Mean, range, and median values for TSK, PHODA-SeV, FABQ-W and PA subscales, PCS, CES-D, QBPDS, NPRS, age, and symptom duration are presented in Table 1. Table 2 provides comparison of normative values for participants with LBP in this study (which were lower) and 4 other studies [29,31–33]. Table 3 provides a comparison of group data for trunk mechanical variables in this study and existing data [3] which used similar methods. Data for five participants were excluded from analysis due to either technical difficulties with data recording (n = 3) or failure of modelled data to adequately fit the recorded data of trunk mechanical properties (n = 2). There was a positive linear association between kinesiophobia (TSK) and trunk stiffness in response to a forward perturbation ($r^2 = 0.33$, $P<0.03$, Table 4, Figure 2). Further exploratory analysis of participants split into 'high kinesiophobia' and 'low kinesiophobia' groups based on the median TSK value (score of 38), showed higher trunk stiffness in response to forward perturbation for those with higher TSK ($P = 0.03$, Figure 3) but not backward perturbation ($P = 0.15$) (Table 5). Likewise, when participants were split into 'high' and 'low' fear avoidance groups according to the median FABQ –W and PA values, trunk stiffness was significantly greater for the "high" than "low" group during forward perturbations for the FABQ-Work subscale ($P = 0.00$). Trunk stiffness (high/low) groups for the forward perturbation were not significantly different based on scores from the FABQ-Physical Activity subscale ($P = 0.06$), nor were trunk stiffness groups significantly different during backward perturbations (Table 5). There was no significant correlation between trunk damping and kinesiophobia (Table 5) or between trunk stiffness or damping and the other psychological measures relevant to the fear-avoidance model (PHODA-SeV, PCS). The context-specific kinesiophobia measure that was related to the participant's perceived harmfulness of the experimental task (PHOET) was not correlated with any mechanical property (Forward and backward stiffness $P = 0.32$ and 0.23, Forward and backward damping $P = 0.45$ and 0.84, respectively). Further, other measures of depression (CES-D), disability (QBPDS), pain intensity (NPRS) and age were not associated with trunk mechanical properties (Table 4). Pain was not worsened by testing (pre-test pain 2.7(2.1)/10 vs. post-test pain 2.6(2.3)/10), but the perceived harmfulness of the experimental task, as measured by the PHOET, reduced from a pre-test value of 42(22.3)/100 to post-test value of 23.2(22.6)/100).

Discussion and Conclusion

This study provides partial support for the hypothesis that psychological aspects (i.e., kinesiophobia) are not independent from the biological presentation (i.e., trunk mechanical properties) of LBP. Consistent with our hypothesis, higher measures of kinesiophobia (TSK) were associated with higher measures of trunk stiffness in response to a forward perturbation. However, trunk damping did not correlate with psychological measures. When data were further probed by stratification into groups with higher and lower scores on measures of psychological features, those with high measures of kinesiophobia (TSK) and fear avoidance beliefs (FABQ) had greater trunk stiffness in response to forward perturbations. The observations of this study imply that neither biology nor psychology should be considered in isolation for investigation or management of this multidimensional disorder.

Despite the relationship between high trunk stiffness and kinesiophobia, trunk mechanical properties were not associated with pain-related fear measures, such as perceived harmfulness (PHODA-SeV, PHOET) or pain catastrophizing (PCS). Trunk

Table 1. Group data for psychosocial variables.

	Mean (SD)	Range	Median
TSK	36.3/68 (7.0)	23–49	38
PHODA-SeV	35.7/100 (14.2)	9.4–56.8	38.7
FABQ-W	13.2/42 (11.4)	0.36	12
FABQ-PA	11.9/24 (5.3)	3–20	11.5
PCS	14.4/52 (8.2)	3–31	13
CES-D	11.5/60 (11.5)	4–25	9.5
QBPDS	25.7/100 (13.8)	8–57	23
NPRS (Pre-Test)	2.7/10 (2.1)	0–6.5	2
PHOET (Pre-Test)	42/100 (22.3)	10–85	40
Age	43.4 (13.2)	27–65	40
Current episode duration (weeks)	35.8 (23.3)	1–60	

TSK = Tampa Scale for Kinesiophobia, PHODA-SeV = Photographs of Daily Activities Short electronic Version, FABQ – W and PA = Fear Avoidance Beliefs Questionnaire - Work and Physical Activity subscales, PCS = Pain Catastrophizing Scale, CES-D = Center for Epidemiological Studies – Depression scale, QBPDS = Quebec Back Pain Disability Scale, NPRS = Numeric Pain Rating Scale, PHOET = Photograph of Experimental Task.

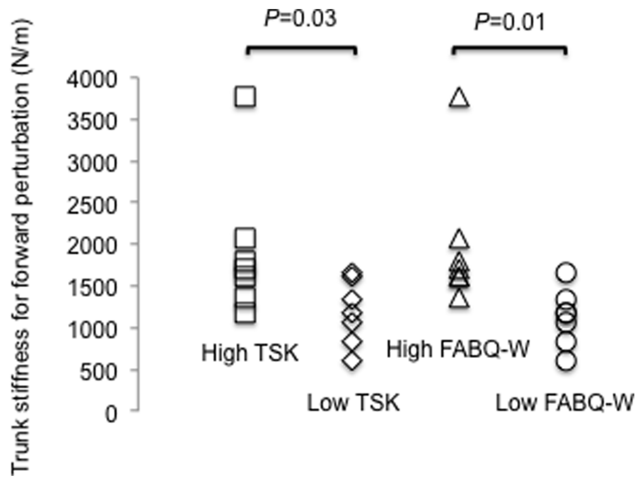


Figure 3. Trunk stiffness for forward perturbation for individuals with high and low kinesiophobia (TSK) and fear avoidance beliefs (FABQ). TSK = Tampa Scale for Kinesiophobia, FABQ-W = Fear Avoidance Beliefs Questionnaire-Work subscale.

mechanical properties were also not associated with measures of disability (QBPDS) or depression (CES-D). Catastrophizing is proposed to initiate the fear-avoidance event cycle, and disability and depression are identified as consequences of elevated pain-related fear and avoidance. One interpretation of the present data is that biomechanical manifestations of pain (i.e., elevated trunk stiffness and increased superficial trunk muscle activity which is likely to contribute to the increased stiffness) are most closely associated at the pain-related fear stage of the fear-avoidance model, rather than its hypothesised precursor, catastrophization.

The basis for the significant association between mechanical properties and kinesiophobia, but not the preceding component of catastrophizing or resulting disability and depression is unclear. One possible explanation is that the proposed steps of the fear avoidance model are non-linear, and there are other ways the human system responds to catastrophizing and disability, which are not represented or manifested through these mechanical behaviors. Pain intensity and/or symptom duration could also play a role in reported fear-avoidance and distress levels, and it is important to acknowledge the relatively low pain intensity values (2.7/10 (2.1)), and persistent and recurrent symptom duration (9 months) of the participants in this study.

The lack of significant relationship between biological properties and the PHODA-SeV, PHOET, and PCS is perhaps reflective of the context or interpretation of the questionnaires. A plausible explanation for the correlation between TSK and trunk mechanical properties in the absence of relationship with the other fear-avoidance related questionnaires might be explained by wider consideration of psychological variables in this measure. The TSK contains items pertaining to a wide spectrum of beliefs (e.g., pain will increase or re-injury will occur if they increased their physical activity or exercise level; something is dangerously wrong with

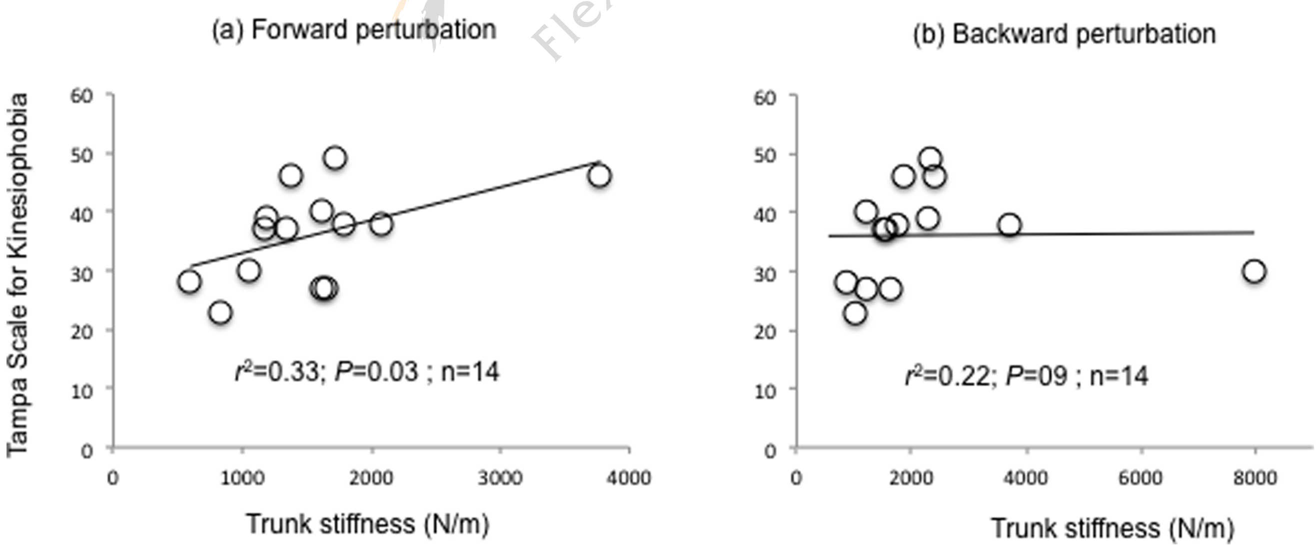


Figure 2. Correlation between TSK and trunk stiffness in response to (a) forward, and (b) backward perturbations.

Table 2. Reported values for Tampa Scale for Kinesiophobia (TSK) for people with low back pain.

Study	Number of participants	TSK
Current study	19	36.3 (7.0)
Nicholas et al [31]	70	41.4 (9.0)
Smeets et al [32]	53	39.0 (6.5)
	58	38.7 (6.9)
	61	39.7 (7.1)
	51	37.8 (7.0)
Roelofs et al [33]	482	43.2 (8.4)
Leeuw et al [29]	85	42.0 (6.2)

their LBP; they are at a greater risk of injuring themselves; pain equates to injury or danger; and they are being delegitimized). In contrast, FABQ items attempt to gain insight on: the heaviness or monotonous behaviour of their work, normal work ability, return to work expectancy, beliefs related to pain serving as an indicator that they should stop their activity, the belief that feeling pain serves as an accurate measure that something is dangerously wrong. Further, the PHODA-SeV (and PHOET) are merely asking the participant to consider which activities they consider harmful or damaging to their back and the PCS primarily contains questions related to catastrophizing/perseverating thoughts (e.g., "I keep thinking about how much it hurts") and questions related to fear, worry, and anxiety. It could also be that the psychometric variables of the TSK are more sensitive to the particular measures of motor control included here.

Clinical Relevance

An interpretation of the results is that kinesiophobia is more closely associated with trunk mechanical properties than other psychological factors (fear avoidance beliefs, pain catastrophizing thoughts, and depression). This finding highlights the interaction between kinesiophobia and trunk control as a potential target for future work addressing questions of causality and design of interventions.

Integration of a biopsychosocial perspective into the practice of pain management is well accepted as the gold standard of care, but disparity could arise if clinicians choose to focus effort on either a biomedical or psychological approach in isolation. The potentially false rationale for incorporating this dualistic philosophy could stem from a misleading judgement that either the mechanical factors or psychological factors are a stronger mediator of pain and/or pain behaviour, and hence, only focus the intervention along one of these domains. Another commonly held perspective is that biomechanical intervention should be augmented with psychological treatments only in cases where patients are considered to have a higher risk of involvement of psychological factors in their presentation, but comprehensive identification of those individuals at higher risk remains a challenge. Results of this study can be interpreted to suggest that neither domains should be considered in isolation, and supports the rationale to combine biomechanical knowledge with psychologically informed principles throughout the assessment, treatment planning, and implementation phases of pain management. This appears particularly relevant for those individuals who exhibit higher fear of pain/injury and avoidance behaviour.

Limitations

The results of this study should be discussed with consideration of several methodological limitations. In relation to the participant profiles, measures related to kinesiophobia deserve discussion. The TSK scores (36(7), range 23–49) were obtained from participants (n = 19) who were predominantly not seeking treatment for their LBP. If TSK values from this study (Mean = 36.3 (7.0)) are compared with TSK measures from other larger LBP studies [29,31–33], it is evident that our population, while perhaps more generalizable in terms of a more typical LBP population, does not represent a highly kinesiophobic or fear avoidance presentation. For example, in the Leeuw et al. study [29] participants were excluded if they held TSK scores <34, whereas in this study only 9 of the 14 participants had a TSK score >34. Furthermore, the FABQ median split values used in this study (FABQ-W = 12, FABQ-PA = 11.5) are well below proposed elevated cut-off values (FABQ-W >34, FABQ-PA >15) used in previous studies [34] to identify individuals with high fear-avoidance beliefs. A further issue is that the participant sample size for this initial exploratory study (n = 19) may lack sensitivity to detect smaller effects. A follow-up study with a larger sample size is required to apply more vigorous statistics (i.e., multiple linear regression analysis, Bonferroni correction) and draw more robust conclusions related to this preliminary, exploratory finding. This is part of ongoing research.

Future Directions

Results imply that trunk stiffness and kinesiophobia might serve as important moderators and/or mediators of persistent and

Table 3. Current and published data for trunk mechanical properties.

		Forward Perturbation		Backward perturbation	
Study		Damping (Ns/m)	Stiffness (N/m)	Damping (Ns/m)	Stiffness (N/m)
Hodges et al [3]*					
Low back pain	Mean (SD)	17 (20)	1997 (474)	63 (39)	2035 (533)
Control	Mean (SD)	55 (37)	1641 (376)	91 (34)	1814 (471)
Current study					
Low back pain	Mean (SD)	94 (69)	1556 (753)	194 (120)	2132 (1791)
	Range	4–164	826–3775	8–325	554–7975
	Median	88	1491	218	1654

*Data for the current study relate to a perturbation induced by a removal of smaller load than that used in the study by Hodges et al. [3].

Table 4. Regression analysis (r^2, *P*-value) between mechanical properties and psychosocial measures.

	Forward stiffness		Backward stiffness		Forward damping		Backward damping	
	r^2	*P*-value	r^2	*P*-value	r^2	*P*-value	r^2	*P*-value
TSK	0.33	0.03*	0.22	0.09	0.02	0.60	0.24	0.07
PHODA-SeV	0.04	0.47	0.01	0.75	0.11	0.26	0.00	0.84
FABQ – W	0.18	0.12	0.01	0.69	0.01	0.69	0.12	0.22
FABQ – PA	0.21	0.12	0.04	0.50	0.05	0.47	0.03	0.60
PCS	0.21	0.10	0.01	0.77	0.02	0.66	0.10	0.23
CES – D	0.02	0.62	0.00	0.87	0.20	0.11	0.03	0.59
QBPDS	0.05	0.46	0.01	0.82	0.07	0.35	0.00	0.97
NPRS	0.00	0.99	0.01	0.82	0.07	0.36	0.00	0.33
Age	0.00	1.00	0.09	0.29	0.05	0.44	0.10	0.26

*- $P<0.05$.
Stiffness (K) = (N/m), Damping (B) = (N s/m), TSK = Tampa Scale for Kinesiophobia, PHODA-SeV = Photographs of Daily Activities Short electronic Version, FABQ - W = Fear Avoidance Beliefs Questionnaire - Work subscale, PCS = Pain Catastrophizing Scale, CES-D = Center for Epidemiological Studies – Depression scale, QBPDS = Quebec Back Pain Disability Scale, NPRS = Numeric Pain Rating Scale.

recurrent LBP. This provides prioritization for future multi-system, biopsychosocial, and applied physiology investigative models to determine if pain management interventions aimed at targeting trunk mechanical properties and kinesiophobia reduce persistence or recurrence of LBP. Various movement based, cognitive and behavioural intervention strategies are worthy of investigation. The relationship between trunk mechanical properties and other pain psychology models (acceptance and commitment, misdirected problem solving, self-efficacy, and stress-diathesis) [35] and their accompanying psychological processes (i.e., cognitive flexibility in beliefs, attempts to solve problem, beliefs about the controllability of pain and coping skills, stress and anxiety) were not investigated. Likewise, other important psychological processes (i.e., attention and emotion regulation, distortion, expectations, helplessness, locus of control, stop rules, overt behaviour) and social-cultural-religious-environmental factors (i.e., spouse/co-worker/supervisor/spiritual support, job control, effort-reward imbalance, over-commitment) were not addressed and are important considerations.

Trunk stiffness and damping are one aspect of motor control, and other measurable dimensions, such as movement variability and movement-based subgroups could provide further context regarding the participant heterogeneity. The motor control task involved in this study is a measure of the participant's automatic postural response and requires only slight forward or backward trunk movements, which may not reflect more planned and functional movement tasks that could potentially be more 'fear inducing' to the participant (i.e., forward bending, rotation of trunk or lifting). There has been a recent call in the literature to prioritize research aimed at providing a better understanding of the mechanisms by which yellow flags can affect the development of persistent pain and disability [36]. Physiology based studies, which examine both the motor control and psychological systems are ideally suited to serve this role and are part of ongoing research.

Conclusion

The data suggest fear of movement (as measured by the TSK) relates, at least weakly, to trunk mechanical properties, which are considered to be an important component of the biological presentation of people with LBP. These findings lend further support to the necessity to recognise the interaction between biomechanical and psychological aspects of LBP rather than their consideration in isolation. It is possible that other psychosocial dimensions or pain psychology models may be related to biomechanical features (i.e., trunk mechanical properties, muscle activity, and movement patterns) in specific subgroups of LBP. Further integration of other potentially modifiable systems and

Table 5. *P*-values (independent t-tests) for comparison of mechanical properties between groups stratified by median value of psychosocial variables.

	Forward stiffness	Backward stiffness	Forward damping	Backward damping
High TSK (>38)	**0.03***	0.15	0.57	0.15
High FABQ-W (>12)	**0.01***	0.49	0.29	0.49
High FABQ-PA (>11.5)	0.06	0.21	0.80	0.21
High PCS (>13)	0.22	0.84	0.65	0.84
High PHODA-SeV (>38.7)	0.22	0.72	0.21	0.72

* = $P<0.05$.
Stiffness (K) = (N/m), Damping (B) = (N s/m). TSK = Tampa Scale for Kinesiophobia, FABQ-W & PA = Fear Avoidance Beliefs Questionnaire-Work & Physical Activity subscales, PCS = Pain Catastrophizing Scale, PHODA-SeV = Photographs of Daily Activity – Short electronic Version.

more thorough investigation of the components within various pain psychology models hold promise in provision of a broader understanding of this multidimensional disorder.

Altered Postural Sway and Fear of Fall in Patients Suffering from Non-specific Low Back Pain

Abstract

Objective: The purpose of this study is to determine whether balance response of low back pain patients is different from healthy controls under various up right standing conditions, and also to find out whether body sway is related to the fear of fall in low back pain individuals.

Method: A sample of 130 subjects was taken in the study through convenient sampling. The postural sway of the subjects was analyzed by using a Sway meter and Fear of Fall was calculated by using a Fall Efficacy Scale.

Result: The results show that greater sway occurs in the patients suffering with Low Back Pain than compared to healthy control group, and FES value and TSOFEC value are correlated to each other (r value=0.23).

Conclusion: Thus the study concludes that patients with low back pain exhibit greater postural sway than healthy controls and the decreased postural stability in people with low back pain is correlated with fear of fall when extra stress has been laid on the balancing system.

Keywords:

Introduction

Human postural balance relies on information from somatosensory, vestibular and visual systems. Postural stability depends also on the efficiency of the motor function: joint stability and muscle activity. The performance of the postural balance system is affected by age, neurological dysfunctions, cerebro cranial injuries, and motor organ diseases [1].

A vital role in maintaining balance is played by the spine. Dysfunctions of the spine influence on control of posture in upright position. Lower back pain is a significant social problem. Low back pain is usually defined as pain, muscle tension or stiffness localized below the costal margin and above the inferior gluteal folds, with or without leg pain (sciatica) [2].

Low back pain (LBP) is a substantial health problem. It affects up to 80% of the adult population and accounts for considerable healthcare and socioeconomic costs [3].

The most used classification for pain in the lumbar spine by clinicians is specific or nonspecific LBP. A specific low back pain diagnosis (about 1-2% of all patients with early low back pain) is attributed to Low back pain, referring to any diagnosis from a systemic disease, infection, injury, trauma, cauda equine or structural deformity. Nerve root pain usually represents about 5% of the pain in patients with a disc prolapses and spinal stenosis [4].

Approximately 90% cases of back pain have no identifiable cause and are designated as Nonspecific. Non-specific low back pain means that the pain is not due to any specific or underlying disease that can be found. It indicates the structure problem of spine. It is thought that in some cases the cause may be a sprain (an over-stretch) of a ligament or muscle [5]. And other common cause like unaccustomed activities, poor posture, muscular, strain, obesity arthritis of spine and occupational cause [6].

Low back pain can be acute sub-acute or chronic patients with acute low back pain is usually defined as the duration of an episode of low back pain persisting for the less than 6 week; sub-acute low back pain as low back pain persisting between 6 to 12 week; chronic low back pain persisting for 12 week or more [5].

Posture sway in quite standing is often studied as a measure of posture control. Many instrument ranging from the simple once like lord's sway to the more sophisticated instrumentation, post urography, utilizes force plate to measure Ground Reaction Force, are used to measure the postural sway [7].

The purpose of this study is to determine whether balance response of low back pain patients is different from healthy controls under various up right standing conditions. It is also determined in the present study whether body sway is related to the fear of fall in low back pain individuals.

Methodology

A collective sample of 130 human subjects between age group 40-73 years, was selected by convenient sampling. The subjects were recruited from the orthopedics department of LLR Hospital Kanpur. An approval by the Institutional Review Board was granted and an informed consent was obtained from each subject.

Inclusion criteria

- Person with nonspecific low back pain for at least 6 weeks age 40-73 year.
- Participants should have at least 1 episode of low back pain prior to study [8].
- Normal lower extremity in neurological examination.
- Low back pain more severe than leg pain [9].
- Faller and non-faller low back pain patients are included in the study [10].
- Both male and female patients participated in study [10].

Exclusion criteria

- More prominent radicular leg pain.
- Previous spinal surgical application.
- Pregnant ladies are excluded.
- Patients with herniated disc (PIVD) [9].
- Specific spinal pathology (e.g. malignancy inflammatory joint, infection) [8].

Protocol

This is an experimental study performed in LLR hospital Kanpur. A sample of 130 subjects (100 in LBP Group and 30 in healthy Control Group) was taken in the study. The participants were selected on basis of exclusion and inclusion criteria. A signed consent was obtained from each participant then procedure was fully explained to the patients.

Procedure

The participants were explained about the need of the study. Then the details required for responding to the scale were given to the subjects. One data collection session included two tests.

- Sway determination by using a sway meter
- Fear of fall determination by using a FES (fall efficacy scale) scale.
- Sway was calculated in our study by using a sway meter and in this one data collection session included tasks which were performed 3 times to test for reliability. The participants stood barefoot on the floor as well as on the foam with their feet no more than 3 inches apart while the Fear of fall was calculated by using on FES Scale consisting of 10 questionnaires.

Sway

130 subjects participated in the study, among which 100 participants belonged to the LBP group, while 30 participants belonged to the healthy control group. In this study postural sway in standing was analyzed with sway meter for both the groups. Sway meter was snugly fit at the ASIS sway meter was placed posterior to subject. Subjects were asked to stand on floor as well as on foam, maintaining a distance of 3 inches between the feet. A graph sheet was placed behind the subject. Graph sheet was leveled in such a way that the rod of sway meter was maintained in horizontal position when starting the measurement graph sheet was secured to prevent displacement during measurement. Subjects were instructed to keep their hands by their sides and stand in erect position. Starting point is marked in graph sheet before taking sway. Each trial was 30 sec subject was given rest period after each trial. Total four tasks were performed by the participants by challenging either the proprioception or the visual system as shown in Table 1.

S.no.	Visual	Proprioception
1	Eyes open	Stable support
2	Eyes closed	Stable support
3	Eyes open	Foam
4	Eyes closed	Foam

Table 1: Four tasks combination with challenged visual and proprioception system.

Then for each task 3 trials were taken. Total 12 trials were taken among which, 6 trials on foam with eyes open and eyes closed and six trials on floor with eyes open and eyes closed. After taking the sway, the small boxes in graph sheet were being counted, in vertical length and horizontal length.

Fall efficacy scale

The participants were explained about the aim of study. The scale known as FES (Fall Efficacy Scale) was used for the assessment procedure. In this patients were asked 10 questions, in which, one quoted as very confident, whereas ten as not confident at all. A total score of greater than 70 indicated that the person had a fear of falling while a score less than 70 showed the person had no fear of fall.

Data Analysis

The data was managed on excel sheet and was analyzed using SPSS (Statistical package for social sciences) software version 17.0. In order to analyze the sway alteration between the experimental group and the control group "t Test" was used while a "Pearson Correlation Test" was performed to find out the relation between sway and Fear of Fall. Descriptive statistics and correlation values were calculated between various variables for all statistical tests the level of significance set as $P \leq 0.01$ and $P \leq 0.05$.

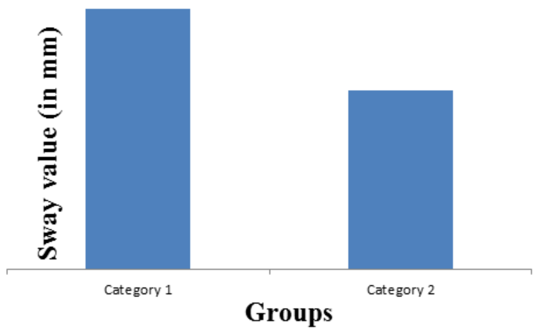
Result

The result was evaluated on the basis of the readings obtained through the scales. The minimum age of the subjects was taken as 40 ± 9.55 years and the maximum age was 73 ± 9.55 years (Table 2).

	Minimum	Maximum	S.D
Age	40	73	9.55

Table 2: Basic characteristic of low back pain patients.

The mean of total sway on foam with eyes open for the control group is calculated as 573.65 and the standard deviation as 300.49. The mean of total sway on foam with eyes open for the experimental group is 837.02 while the standard deviation as 632.66. This shows that the sway is more significant in the experimental group (Graph 1, Table 3).

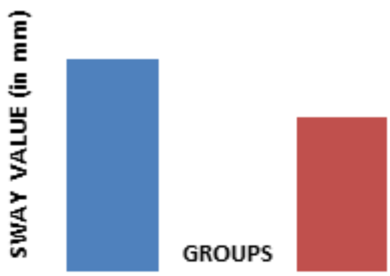


Graph 1: Total sway on foam with eyes open in control group and experimental group.

SWAY	Mean		SD	
	Control	Experimental	Control	Experimental
TSOFOE	575.65	837.02	300.49	632.66
TSOFCE	849.27	1163.9	552.14	765.47
TSOGOE	292.86	529.28	152.99	442.26
TSOGCE	360.74	442.54	194.11	479.03
TSOFOE=Total sway on foam with eyes open				
TSOFCE=Total sway on foam with eyes closed				
TSOGOE=Total sway on ground with eyes open				
TSOGEC=Total sway on ground with eyes closed				
S.D=Standard deviation				

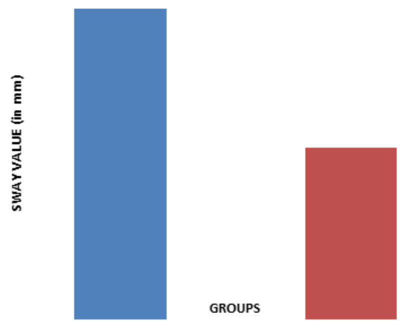
Table 3: Total sway in low back pain group and control group.

The mean value of total sway on foam with eyes closed for the control group is calculated as 849.27 and the standard deviation as 552.14. The mean of total sway on foam with eyes closed for the experimental group is calculated as 1163.90 and standard deviation as 765.47 (Graph 2, Table 3).



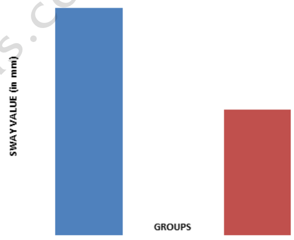
Graph 2: Total sway on foam with eyes closed in control and experimental group.

The mean of total sway on ground with eyes open for the control group is calculated as 292.86 and standard deviation as 152.99. The mean of total sway on ground with eyes open for the experimental group is calculated as 529.28 and standard deviation as 442.26 (Graph 3, Table 3).



Graph 3: Total sway on ground with eyes open in control and experimental group.

The mean of total sway on ground with eyes closed for the control group is calculated as 360.74 and standard deviation as 194.11. The mean of total sway on ground with eyes closed for the experimental group is calculated as 442.54 and standard deviation as 479.03 (Graph 4, Table 3).



Graph 4: Total sway on ground with eyes closed in control and experimental group.

The t value for the total sway on foam with eyes open is obtained as 2.18 while the P value as 0.05, which is a significant value and this shows that the sway is more significant in the low back pain group than the control group when the level of significance is 0.05.

The t value for the total sway on foam with eyes closed is obtained as 2.09 while the P value as 0.02 this show that the sway is more significant in low back pain group than control group when the level of significance is 0.05.

The t value for the total sway on ground with eyes open is obtained as 2.87 while the P value as 0.003 this show that sway is significant in low back pain group than control group when the level of significance is 0.01.

The t value for the total sway on ground with eyes closed is obtained as 0.91 while the P value as 0.02 this shows that sway is significant in low back pain group than control group when the level of significance is 0.05 (Table 4).

Sway	T value	P value
TSOFEO	2.18	0.05**S
TSOFEC	2.09	0.02**S
TSOGOE	2.87	0.003*S
TSOGEC	0.91	0.02**S
*Level of significance 0.01 ** Level of significance 0.05		
TSOFOE= Total sway on foam with eyes open		
TSOFCE=Total sway on foam with eyes closed		
TSOGOE=Total sway on ground with eyes open		
TSOGEC=Total sway on ground with eyes closed		
S=significance		

Table 4: Total sway in low back pain group and control group.

The r value for the Correlation between FES and total sway on foam with eyes open is 0.11 while the P value is 0.25 which is not significant (when the level of significance is 0.05). Hence shows that FES value and TSOFOE value are not correlated to each other.

The r value for the correlation between FES and total sway on foam with eyes closed is 0.23 while the P value 0.02 which is a significant value (when the level of significance is 0.05). Hence shows that FES value and TSOFEC value are correlated to each other.

The r value for the Correlation between FES and total sway on ground with eyes open is 0.14 while the P value is 0.17 which is not significant (when the level of significance is 0.05). Hence shows that FES value and TSOGOE value are not correlated to each other.

The r value for the Correlation between FES and total sway on ground with eyes closed is 0.13 while the P value is 0.21 which is not significant (when the level of significance is 0.05). Hence shows that FES value and TSOGEC value are not correlated to each other (Table 5).

	TSOFEO		TSOFEC		TSOGEO		TSOGEC	
	p value	r value	p value	r value	p value	r value	p value	r value
FES	0.25	0.11	0.02**	0.23	0.17	0.14	0.21	0.13
	NS		S		NS		NS	
TSOFOE=Total sway on foam with eyes open								
TSOFCE= Total sway on foam with eyes closed								
TSOGOE=Total sway on ground with eyes open								
TSOGEC=Total sway on ground with eyes closed								
FES= Fall efficacy scale								
S=Significance and NS=Not significance								
*Level of significance 0.01 ** Level of significance 0.05								

Table 5: Correlation with total sway and FES.

Discussion

The purpose of this study is to find the difference in sway in case of LBP group and control group (consisting of healthy subjects) as well as to find the relation between the postural sway and fear of fall in low back pain individuals. During standing an individual normally exhibits small range postural shifts or postural sway cycling intermittently from side to side and from heel to toe. In normal individuals the AP sway is approximately 12 degrees [11].

But this sway may vary in different situation as we found in our study the sway was increased in the LBP group as compared to the sway in the control group which consisted of the healthy individuals. The result showed a significant difference between the sway in the LBP group and the control group [12]. The altered sway pattern in both the groups may underline the role of "Pain Inhibition" in the observed postural response [13].

The sway was examined under four conditions on floor with eyes closed and on the foam with eyes open as well as with eyes closed in order to alter the visual proprioception and joint proprioception so as to challenge the balance system of our body. It is noted that visual deprivation caused an increase in postural sway in both the groups [1,14].

Also the results showed a positive correlation between the perceived fear of fall and sway in LBP individuals. This correlation has been found positive only in the case when the persons with LBP were standing on 'Foam' with eyes closed. The proposed reason may be when the complexity of the task increased the postural stability decreased in persons with LBP [15].

During standing on foam the CNS of the healthy person significantly up weighted the proprioceptive signals from the Paraspinal muscles and down weighted those from ankle muscles to control postural balance. As standing on foam is less reliable proprioceptive input from the ankle joint. Therefore the CNS should rely more on the proprioceptive input from other joints such as lumbosacral region to keep the postural balance. These findings suggest strongly that the persons with recurrent LBP have altered postural control. Moreover, the CNS of the persons with LBP seemed to select the same postural control strategy (i.e. proprioceptive control at the ankles) as in normal bipedal standing on stable support surface, showing a decrease in postural control variability. This postural strategy leads to less stable postures when postures when postural demands increase and also may generate a fear of falling in the individuals [15,16].

Another reason for the positive correlation between fear of fall and sway may be fear avoidance model according to which pain related fear leads to the avoidance or escape from activity which further leads to disability and inability to maintain balance [17-19].

Thus our study aims to correlate the fear of fall and sway in LBP individuals so that in future attempts can be made through the treatment protocol to decrease or avoid these difficulties.

Strength and limitations

The strength of the current work is that it may be that only study which used a sway meter to measure sway discriminated between LBP group and non-low back pain group. The control of standing balance is a task of maintaining the body COM within the limits of BOS achieved by providing force on the support surface excursion of the COP the point of application of the ground reaction force measured by a force plate has been widely used to represented postural sway as an index of balance control. However these measures involve technical devices that can be usually and require processing protocols that can make them unfeasible for many clinics and research facilities. The need for a simple measure of postural sway exits due to the issue of balance problem and risk of fall. So this low technical sway meter was designed to address the need of clinicians and researchers with limited resources. It involves no electronics or computer processing. Thus assessment can be conducted in variety community setting and health care facilities.

The study also has a few limitations.

- First limitation is linked to the absence of cognitive status of participants.
- A final limitation is the inability to measure the alteration in sway with the orientation of the vestibular system.
- The limitation with respect to the sway include the fact that dynamic sway was not evaluated
- Absence of random sampling.

Future research

Future study should focus on the development of new experimental protocols based for example on 3D analysis to clearly verify the correlation between fear of fall and sway. These studies should evaluate the importance of the correlation for its influence on each anatomical segment of the body.

Conclusion

Patients with low back pain exhibit grater postural sway than healthy controls. Further the decreased postural stability in people with low back pain is correlated with fear of fall as extra stress has been laid on the balancing system.

A Review of Relationship between Fear Avoidance Beliefs and Postural Stability in Non Specific Chronic Low Back Pain

Abstract

Introduction: Low back pain (LBP) is one of the most prevalent diseases in most developed and developing countries, affecting 70% to 80% of adults at some time during their lives. Recent evidence suggests that psychosocial factors especially fear-avoidance beliefs (FAB) are important in predicting patients who will progress from an acute to a chronic stage as well as failure of interventions. The aim of this study is to review the Relationship between Fear Avoidance Beliefs and Postural stability in non specific Chronic Low Back Pain (CLBP).

Methods: In this narrative article we have searched PubMed, CINHAL, APTA and MEDLINE data bases. The key words included: chronic low back pain, fear avoidance beliefs, posture, stability, balance, motor control, center of pressure and force plate. The inclusion criteria were being related to FAB and postural stability and adults with non specific CLBP, in English language, up to 2013, regardless of their study design.

Results: The results showed that psychological factors such as FAB influence the chronicity of LBP, a group of studies indicated that FAB is related to pain and disability. Another group of studies indicated that postural stability is related to pain and disability. The only study on the relationship between postural stability and FAB did not found any significant relationship.

Conclusion: FAB is related to pain and disability. Postural stability is related to pain and disability. More studies with stronger methodology such as larger population with control group are needed for evaluating the relationship of FAB and postural control.

Keywords: Chronic low back pain; Fear avoidance beliefs; Stability; Motor control

Introduction

Low back pain (LBP) is one of the most common health problems which affect 60% to 80% of adults at some time during their lives [1,2]. About 85% of patients with back pain are classified as non specific chronic low back pain [3]. Although most of the time, LBP is a self-limiting disorder and a majority of these patients will improve rapidly [4], half of them has a long history of multiple episodes [5] and in a small group of them (about10%), pain will become chronic [6-8]. This group of patients allocate about 80% of costs to themselves [9]. Consequently, LBP is a major public health problem with an immense socioeconomic burden in most developed and developing countries.

Studies on patients with acute or sub acute LBP reveal several factors influence on progression to chronicity of LBP such as: high level of psychological distress, dissatisfaction with employment, longer duration of symptoms, previous history of LBP, radiating pain and higher initial disability level [10-13], psychosocial factors like the patients attitudes and beliefs, pain and movement related fear, stress, depression, job satisfaction, self confidence and self assurance are very important in CLBP [14,15]. The cognitive-behavior concept of developing chronic pain is appearing as fear-avoidance behavior at early stage. Cox et al. explained in a model the reason of pain exaggeration and the reason of developing pain in to chronic stage in some of the patients while improving in others [16]. According to this model, the patient's fear of pain, and subsequent avoidance behavior, are determined by the relation between sensory and emotional components of pain. The hypothesis is that the patients believes and fears concerning symptoms and activity lead to unhelpful ways of managing symptoms, including avoidance behaviors, decreasing activities of daily living, job and recreation which reflect a state of not feeling well. Also failing to diagnose factors which influence their condition can lead to use an inappropriate treatment approach.

In individuals with LBP, the Fear-Avoidance Belief Questionnaire (FABQ) quantifies pain-related fears and believes about the necessity of changing the behavior of pain avoidance [17]. Pain related fear refers to a condition in which the patient has an excessive, irrational, and debilitating fear of physical movement and activity, resulting in feelings of vulnerability to painful injury or re-injury [18,19]. Biomechanical factors such as strength or endurance, flexibility spinal stability and neurophysiologic factors have been studied in several investigations [20-22]. It is important for physicians and physiotherapists to have enough information in this area in order to be able to recognize the obstacles of the patients' improvement and adopt an appropriate strategy accordingly.

Optimal postural control is an essential requirement to perform daily activities. Postural stability is a component of postural balance which indicates the ability of maintaining a certain posture and is described by center of pressure (COP) excursion [23,24]. Many factors may contribute to control postural stability including age, neurological or musculoskeletal disorders such as LBP and biomechanical factors such as muscle endurance [21,25]. The influence of LBP on postural balance is complex and affected by co-existing factors: pain, fear of pain, positive neurologic findings, adoption of an alternate movement strategy, and low muscular conditioning [24,26-30]. Several studies have shown that patients with CLBP have some problems for postural control [31,32]. Fear-avoidance believes have been hypothesized as the most important psychosocial factor in predicting disability and work time loss among patients with chronic low back pain (CLBP). So identifying potentially modifiable determinants of disability in patients with LBP provides an opportunity to expand strategies of controlling socioeconomic problems. Many studies have assessed the relationship of either impairment or psychosocial factors with disability and pain [33-36], but to our knowledge, relationship between the level of Fear-Avoidance Belief (FAB) and the parameters of postural stability is not well studied and it needs more studies. The aim of this study is reviewing the studies on the relationship between psychosocial factors especially pain related fear with postural stability in non specific chronic low back pain.

Methods

In this narrative review article the PubMed, CINHAL, APTA and MEDLINE data bases were searched for articles on relationship between pain and pain related fear and postural stability. The related key words included: back pain, chronic low back pain, fear avoidance beliefs, postural stability, postural control, force plate and center of pressure. The criteria for evaluation of the articles were included: their title being related to the topic (defining the relationship between pain related fear, pain, disability, postural stability and postural control), with any design, up to 2013 published in English. Twenty five articles had the inclusion criteria. The studied out comes included activity and reaction time of trunk muscles, center of pressure excursion (sway), fear avoidance beliefs, pain and disability. Studies which did not evaluate the relation of these outcomes were excluded.

Results

According to the inclusion and exclusion criteria 25 articles were found which met the inclusion and exclusion criteria. These studies were summarized in Table 1 and 2. The studies were divided in 3 categories: studies on relationship between pain, disability and FAB, studies on the relationship between pain, disability and postural stability and studies on relationship between FAB and postural stability.

Pain, disability and fear avoidance beliefs

Psychological factors may be related to the onset, development, and treatment outcome of spinal pain. Strong evidence also shows that psychosocial variables generally influence more than biomedical or biomechanical factors on chronic back pain [37-43]. Recent evidence suggests that psychosocial factors are important in predicting patients who will progress from an acute to a chronic stage as well as failure of interventions [13,14]. Patients with chronic pain often demonstrate anxiety and depression [15].

Several studies have shown the relationship between pain, FAB and disability in patients with CLBP [38-43]. With regard to psychosocial factors, a growing body of published data has provided evidence that elevated pain-related fear predicted disability in patients with acute and chronic LBP [35,41-43]. People who experience pain-related fear will avoid activities they associate with increased risk for pain or (re) injury [18,19]. Therfore pain-related fear have a negative impact on the results of performance testing [35,44]. Correlation analysis in a study by Guclu indicated a significant but positive weak association between the severity of pain and fear avoidance (physical, work and overall) [45]. The relation between pain, pain related fear and functional performance is weak or non-existent in patients with CLBP [46]. A hospital case-control study in Iran, compared the psychological features in patients with low-back pain. Patients' levels of depression and anxiety were related to occupational background. Longer duration of illness was also accompanied by higher levels of anxiety and depression [33]. Another study indicated that Pain was positively related with fear-avoidance beliefs, catastrophizing, and anxiety. In addition, job had a moderating effect on the relationship between pain and anxiety so that job indicated 24.6% of pain variance [47]. Two review articles by Leeuw [48] and Akhbari [49] indicated that there is a positive relationship between

Author	Study design	Topic	Results
Lafond et al. [32]	Case-control	Postural balance during prolong standing in low back pain patients	Decreasing of Cop velocity, frequency and excursion
Della Volpe et al. [58]	Case-control	Postural control during dynamic standing in low back pain patients	Increasing of Cop excursion
Luoto et al. [33]	RCT, n=99(LBP), n=61(Healthy)	Reaction time and COP velocity	Postural control was weaker in CLBP and improved after rehabilitation
Mann et al. [24]	Case-control	Postural control in CLBP	Cop velocity was higher in CLBP
Brumagne et al. [26]	Case-control, n=52(LBP), n=33(Healthy)	Postural control in CLBP	Cop excursion was higher in CLBP
Brumagne et al. [54]	Case-control, n=21(LBP), n=24(Healthy)	Postural stability and postural control strategy in persons with recurrent LBP	persons with recurrent LBP use the same postural control strategy even in standing on an unstable support surface
Ruhe et al. [27]	Systematic review	Postural control in CLBP	Cop velocity and excursion were related to LBP but not pain intensity
Ruhe et al. [60]	Case-control, n=77(LBP), n=77(Healthy)	Is there a relationship between pain intensity and postural sway in patients with CLBP	COP mean velocity and sway area are closely related to self-reported pain scores.
Ruhe et al. [61]	Case-control, n=38 (LBP), n=38(Healthy)	Pain relief is associated with decreasing postural sway in patients with CLBP	Alterations in pain intensities are closely related to changes in postural sway.
Takala and Juntura [28]	Cohort, two year follow up, n=430	Role of functional tests in prediction of LBP	Weak performance was related to low stability and endurance
Moseley et al. [30]	Comparative before and after, n=16	Relationship between experimental pain and Postural control in CLBP	Pain causes delay in postural muscle activation
Mazaheri et al. [57]	systematic review	postural sway during quiet standing in LBP	Most studies reported an increased postural sway in LBP or no effect of LBP on postural sway.

Table 1: Studies on Postural control, pain and disability.

Author	Study design	Topic	Results
Crombez et al. [41]	Cross sectional,n=124	Relationship between pain and fear of pain with disability in CLBP	Pain is related to FAB and disability
Klenerman et al. [42]	Cohort, one year follow up,	Role of fear avoidance beliefs in prediction of LBP	7% become chronic (66% due to fear of pain)
Afshar Neghad et al. [64]	Cross sectional n=50	Relation between fear of movement, pain and disability in chronic low back pain	fear of movement, pain intensity and age are related to disability
Akhbari et al. [49]	review	The Fear of Movement/Pain in Musculoskeletal Pain-A Review	fear of pain can be as disabling as pain itself
Gatchel et al. [14]	Cohort, one year follow up, n=221	Role of psychological factors in CLBP	High prevalence of psychological diseases in CLBP
Linton [15]	Systematic review	Role of psychological factors in CLBP and neck pain	clear link between psychological variables and neck and back pain onset
Sajjadian et al. [47]	Cross sectional n=50	fear-avoidance believes, pain catastrophizing and anxiety effects on chronic low back pain in women	Chronic low back pain can be predicted by fear-avoidance beliefs and catastrophizing
Guclu et al. [45]	Cross sectional n=105	The Relationship Between Disability, Quality of Life and Fear-Avoidance Beliefs in CLBP	Higher levels of anxiety, depression, FABQ (work) leads to higher level of disability
Ramond et al. [38]	systematic review	Psychosocial risk factors for chronic low back pain in primary care	Depression,psychological distress, passive coping strategies and FAB were independently linked with poor outcome
Leeuw et al. [47]	Review Paper	The Fear-Avoidance Model of Musculoskeletal Pain: Current State of Scientific Evidence	pain-related fear is associated with catastrophic interpretations of pain, avoidance behaviors, pain intensity and disability
Davis et al. [62]	Cross sectional n=235	Variables Associated With Level of Disability	Disability is related to duration of LBP, higher level of pain intensity and FAB, and stability (velocity in the forward direction
Maribo et al. [43]	Validity, n=97	Postural balance in low back pain patients	No relationship between pain, FAB and COP excursion
Lamoth et al. [32]	Case-control	Relationship between pain and fear of pain with muscle coordination in CLBP	Pain intensity, kinsiophobia and disability were not related to postural muscle function but were due to LBP

Table 2: Studies on pain and fear of pain and disability and postural control.

pain-related fear, pain intensity and disability; in addition, pain-related fear results in poor clinical outcomes.

Pain, disability and postural stability

Several studies have shown that postural control parameters change in CLBP however, there is controversy on relationship between pain and postural control parameters, [32,37,50-56] so that some of them indicated increasing postural sway [53], others have shown decreasing postural sway [51] while in the other studies, there was not any significant relationship between pain intensity and postural sway [54]. Of course one of the two recent systematic review article has revealed that pain results in enhancement of cop excursion [27] while the other systematic review indicated that there is equal number of studies showing increased sway in LBP, or no effect of LBP on sway [57].

In LBP patients, delayed contraction of trunk muscles, which results in reduced stiffness of the spine at the time of initiation of the movement, occurs when the equilibrium of the spine is disturbed by rapid movements of the upper or lower limbs [51,52]. In recent years, it has become evident that muscle pain can interfere with motor control strategies and different patterns of interaction are seen during rest, static contractions, and dynamic conditions [51].

Altered postural adjustments of the trunk muscles during pain are not caused by pain interference but are likely to reflect development and adoption of an alternate postural adjustment strategy [30]. Although postural activation of the deep trunk muscles is not affected when central nervous system resources are limited, it is delayed when the individual is also under stress [57,58].

In CLBP patients, postural stability under challenging conditions such as prolonged standing is maintained by an increased sway in anterior-posterior direction. This alteration in postural strategy may provide a dysfunction of the peripheral proprioceptive system or the central integration of proprioceptive information [59]. These findings point to possible neurophysiologic mechanisms that could help explaining why fear of pain is a strong predictor of pain-related disability [60] (Table 2).

Another study in 2011 has shown postural stability is related to higher level of pain intensity and lower level of pain intensity don't due to alteration of postural stability [61]. A new study showed that disability is related to duration of LBP, higher level of pain intensity, FAB and stability (velocity in the forward direction) [62].

Studies on relationship between FAB and postural stability

The only study of concurrent and predictive validity of postural balance in LBP patients did not found any significant relationship between fear avoidance beliefs and postural stability (COP excursion and velocity) [50]. Baseline and 12-week follow-up results of 97 LBP patients were evaluated. The correlations between CoP measurements and pain, fear of pain, and physical function were poor. There were no significant differences in CoP measurements between patients with no change or deterioration and patients with improvement in pain and back-specific function [50]. Also another study has evaluated the relationship between kinesiophobia and trunk muscles function but they were not related significantly [32]. Correlation analysis in a study by Kusters showed that neither fear of movement and catastrophizing nor pain was related to either reaction time (RT) or movement time (MT) [63]. Another study by Afshar-nezhad also indicated that fear of movement; pain intensity and age are related to disability [64]. Guclu showed that when fear-avoidance (physical, work and overal), increased, disability increased as well [45]. In the study of Crombez et al. [65] a moderately significant relation was found between physical and work fear-avoidance behavior and disability.

Discussion

The aim of this study was to review the relationship between psychological factors focusing on FAB, pain, disability and postural stability.

According to the results, first group of studies showed that psychological factors such as FAB influence the chronicity of LBP; in addition FAB is related to pain and disability.

Another group indicated that postural stability is related to pain and disability. Also a few studies indicated that FAB is related to postural stability in subjects without CLBP but only one study has investigated this relationship in patients with CLBP in which there was not seen any significant relationship between FAB and postural stability.

Sajjadian et al. showed that Pain was positively related to fear-avoidance beliefs, catastrophizing, and anxiety [47]. In her study, fear-avoidance beliefs and catastrophizing explained 45.6% of the variance of the pain. In addition, she revealed that job had a moderating effect on the relationship between anxiety and pain. Her study carried out on women who reported higher level of FAB compared to men [47]. Sions and Hicks [66] explained the lack of a significant relation between fear avoidance and disability in their Hispanic patients, in these patients. It seems that pain intensity and ethnic characteristics are underlying factor for this controversy. Hicks et al stated that fear and avoidance behavior in work is a highly specific finding for disability [67]. George et al. [68] demonstrated that in patients with chronic low back pain, the single predictor of disability was fear avoidance behavior (work). As to the study of Waddell et al. [17], severity of pain and fear avoidance behavior was found to be predictors of disability [17]. The relationship between pain related fear and performance appeared stronger in studies where patients were observed under strictly controlled conditions, and weaker in studies where patients were observed in a less controlled environment [41,69]. However the relationship between pain, fear avoidance beliefs and postural stability was different in these studies. According to the study by Isableu and Vuillerme [70] in quiet standing, postural sway will decrease because of trunk stiffening strategy or ankle strategy but during standing on foam, postural stability will decrease in patients with CLBP compared to healthy subjects; while in another study by Brumagne et al. [54], the results showed that in both quiet standing in a stable surface and unstable surface (foam) is different in patients with CLBP compared to healthy subjects. These results support the hypothesis that in more complex postural conditions postural stability decrease in persons with LBP compared to healthy controls. Ruhe et al. demonstrated a linear relationship between pain intensity and postural sway velocities in both sagital and frontal plans [60], however, the sway velocity in frontal plan increased at a faster rate. In addition, his study confirms the altered postural sway characteristics previously reported in a systematic review of NSLBP sufferers [27]. The most important finding of his study was that higher intensity of pain perception is related to COP measurements which can describe why in some studies pain intensity was not related to the postural stability. Therefore the neurological alteration previously described [30,71-74] may only have an impact on COP measures at medium to high intensities (more than 5 in numeric rating scale of pain). These results are in agreement with observations of Lihavainen et al. [75] who conducted a similar study in a geriatric population, of course, pain was measured based on a subdivision into mild or moderate/severe pain only in their study and the studied population was different characteristically. However, according to using a protocol based on best evidence [60], future studies are not needed to confirm these findings using the same protocol. Considering the inclusion criteria, focusing on those with higher pain intensity to reach significance compared to controls more readily, the results may also interpret the results of studies (e.g. Brumange et al. [54] and Mok et al. [29]), in which there were not significant differences in postural sway between symptomatic individuals and healthy controls because of low pain intensities of the NSLBP participants enrolled. There is evidence that higher COP sway is associated with a higher risk of falling in the elderly [76] therefore the importance of suitable pain control in elderly pain sufferers to avoid falls. Furthermore, as pain interference appears a likely underlying mechanism, the focus of a rehabilitative approach in pain sufferers with increased COP excursions should be on pain reduction rather than proprioceptive training.

As the lower back motor tasks are often considered both painful and threatening by patients, it is hard to distinguish whether performance insufficiency is attributed to pain experience or to pain related cognitions. Only a few studies tried to enable analysis of pain effect apart from cognition effect. Lamoth et al. studied the influence of both parameters (pain and fear of pain) on gait in healthy subjects [77]. Their results show that only pain influenced on gait parameters. Considering subjects awareness of disappearing pain eventually, pain-related fear may not be representative for this population since pain is present continuously and pain-related fear is much more substantial. Kasters [63] and Luoto [33] indicated slower reaction time of patients compared to healthy subjects concluded that the reaction time in CLBP patients was not influenced by cognitions. The contradiction of their studies with findings of previous studies demonstrating a deteriorating role for pain-related cognitions and reaction time performance [64,78,79] may be due to differences in experimental design (i.e. different reaction time tasks).

In sum, there is lack of knowledge concerning the relation between pain, pain-related cognitions and deviations in CLBP patients' motor performance. As it is conceivable that managing pain demands a different treatment approach than managing pain-related cognitions, this knowledge might be useful to increase CLBP therapy effectiveness.

The only recent study of concurrent and predictive validity of postural balance in LBP patients revealed no association between COP measures and pain, fear of pain, and physical function. According to recommendations for COP measures were published in 2010 in order to reduce measurement errors, this recent study may have some errors such as being included all low back patients, not considering age groups and procedure of measuring COP (60 second sampling duration instead of 90 second and 2 trials instead of 3-5 trials) [27,61].

Also, a high level of anxiety increased postural sway in healthy individuals, with an increment of path length in the anteroposterior axis [80]. On the other hand, Lopes found a significantly reduced body sway area and mean power frequency thorough the experiment as well as a negative correlation between anticipatory anxiety and mean sway area when compared to control participants [81]. Levitan et al. also found that patients with social anxiety disorder showed a reduced sway area and a lower velocity in the mediolateral direction during presentation of all blocks of pictures compared to control [80]. His study showed that body sway in patients with social anxiety disorder is smaller than in controls independently of the presence and contents of visual information maybe because the stimulus of anxiety was not enough [80].

To become a short story, it seems that different results of the evaluated studies are due to the way of data collection, population characteristics (physical activity and fitness level and age), inclusion/exclusion criteria, the level of pain, postural stability and fear avoidance beliefs at the beginning of the studies. Also different instruments (the questionnaires and scales for fear avoidance, pain, force plates), different procedures of measuring postural stability (quiet standing or single leg stand or sitting, with open or closed eye and the position of the hands the number of trials, frequency of filtering and capturing) and different outcome measures for postural stability (muscle activity, reaction time, COP displacement, velocity, mean frequency) used in these studies can be consider for variability of their results.

Conclusion

It can be concluded that pain related fear may be one of the factors of failure the treatments of patients with NCLBP. FAB is related to pain and disability. Postural stability is related to pain and disability. More exact studies are needed for evaluating the relationship of FAB and postural control.

Limitations

One of the most important limitations of this study is lack of the statistical analysis and criterion evaluation of the included studies.

Suggestions

It is recommended to evaluate more similar and related studies from other data bases which focus on the topic according to their power as well as using statistical analysis of their data where it is possible.

Physical activity and the mediating effect of fear, depression, anxiety, and catastrophizing on pain related disability in people with chronic low back pain

Abstract

Background

Chronic low back pain is a worldwide burden that is not being abated with our current knowledge and treatment of the condition. The fear-avoidance model is used to explain the relationship between pain and disability in patients with chronic low back pain. However there are gaps in empirical support for pathways proposed within this model, and no evidence exists as to whether physical activity moderates these pathways.

Methods

This was a cross-sectional study of 218 people with chronic low back pain. Multiple mediation analyses were conducted to determine the role of fear, catastrophizing, depression, and anxiety in the relationship between pain and disability. Separate analyses were performed with physical activity as the moderator. Individuals were classified as performing regular structured physical activity if they described on average once per week for > 30-minutes an activity classified at least moderate intensity ($\geq$ 4–6 METs), activity prescribed by an allied health professional for their back pain, leisure time sport or recreation, or self-directed physical activity such as resistance exercise.

Results

Fear, catastrophizing, and depression significantly mediated the relationship between pain and disability ($p<0.001$). However the mediating effect of catastrophizing was conditional upon weekly physical activity. That is, the indirect effect for catastrophizing mediating the relationship between pain and disability was only significant for individuals reporting weekly physical activity ($B = 1.31$, 95% CI 0.44 to 2.23), compared to individuals reporting no weekly physical activity ($B = 0.21$, 95% CI -0.50 to 0.97). Catastrophizing also mediated the relationship between pain and fear ($B = 0.37$, 95% CI 0.15 to 0.62), with higher scores explaining 53% of the total effect of pain on fear.

Conclusions

These results support previous findings about the importance of fear and depression as factors that should be targeted in low back pain patients to reduce back pain related disability. We have also extended understanding for the mediating effect of catastrophizing on back pain related disability. Back pain patients engaged with regular physical activity may require counselling with regards to negative pain perceptions.

Introduction

Low back pain is the musculoskeletal condition with the greatest worldwide burden of disease, defined in terms of disability adjusted life years or years lived with disability [1]. The economic cost to society is considerable, with direct annual costs of treatment in Australia estimated to be $4.8 billion [2], and total treatment costs approximately $9 billion [3]. Despite both pain and disability being associated with a range of psychosocial and physical factors [4–7], the direct pathways that link pain and disability remain unclear. Thus clinicians and researchers are faced with difficulty designing targeted interventions to alleviate the burden of chronic back pain. One theoretical model developed to explain how pain leads to disability is the fear-avoidance model [8,9]. However, despite its popularity for explaining disability, and integration into clinical trials to provide measures of treatment action, there are gaps in empirical support for pathways within the fear-avoidance model.

The fear-avoidance model was originally proposed to explain how exaggerated pain perception was the consequence of a heightened fear of pain and avoidance of social and physical activities [10]. In 2000 the model was updated to suggest that pain may lead to catastrophic thinking, with the subsequent increase in fear and physical disuse contributing to disability and psychological distress [9]. Recently, paths within the fear-avoidance model have been examined in a systematic review of mediation studies [11]. Mediation is a type of statistical analysis that examines proposed causal mechanisms thought to explain the relationship between two variables. This review reported that fear and psychological distress, but not catastrophizing, mediate the relationship between pain and disability. However a number of gaps in the literature were identified with regards to support for causal paths within the fear-avoidance model. First, studies examining the mediating effect of catastrophizing were not sufficiently powered based on recommended sample sizes for this type of analysis (total of 3 studies reviewed, n = 234; range n = 64 to 103), and only one of these studies sampled from a chronic back pain population [12]. The low power, particularly for chronic back pain patients, may explain the disparity between the review conclusions and outcomes from intervention studies that suggest catastrophizing mediates the effect of various physical activity and treatment interventions on back pain related disability [13]. Second, no study examined the first proposed pathway of the fear-avoidance model, which suggests that catastrophizing mediates the relationship between pain and fear [9]. Finally, no information was provided about factors (e.g. physical activity, pain duration) that may moderate pathways within the fear-avoidance model.

In contrast to mediation, which quantifies the effect a potential explanatory variable (e.g. fear) has on the relationship between an exposure (e.g. pain) and outcome (e.g. disability), moderation is an analysis technique that examines whether an external condition influences such a relationship. Within the context of the fear-avoidance model and low back pain, the regular performance of a structured physical activity program (e.g. therapist guided exercise program, cardiorespiratory exercise, self-prescribed trunk exercises) is a potential moderating variable that has not been examined. Adherence to prescribed physical activity or exercise in low back pain patients is typically poor, with reports of non-adherence in 50 to 70% of patients [14,15]. Moreover, physical activity levels have a negative association with disability in patients with chronic low back pain [16]. While it is plausible to suggest that back pain patients who do not engage in regular physical activity exhibit greater fear-avoidance, thus explaining the relationship between higher levels of pain and disability, this has not been well examined.

Therefore we conducted this study to provide further empirical investigation of proposed pathways within the fear-avoidance model in patients with chronic low back pain. The specific objectives of this study were 1) to investigate whether catastrophizing, in combination with fear and psychological distress, mediated the relationship between pain and disability, 2) to investigate whether catastrophizing mediated the relationship between pain and fear, and 3) to examine whether engagement with regular structured physical activity moderated the indirect effect of catastrophizing, fear, and psychological distress on the relationship between pain and disability.

Materials and methods

Study design

This cross-sectional study with mediation analysis used data from people with chronic low back pain, and does not report any outcomes following specific treatment.

Participants

This study was based on data collected from 218 consecutive participants (out of 394 people screened for inclusion) with chronic low back pain from the local community who attended the local University School of Science and Health research facility between June 2011 and July 2016 (Table 1; S1 Table). Sample size estimates for mediation analysis to achieve 0.8 power [17] were based on previous data for the mediating effect of fear and depression on the relationship between pain and disability (a and b pathways $B = 0.40$), and required a minimum of 71 participants. This study was not sufficiently powered to detect significant indirect effects when the a and b paths (exposure to mediator, mediator to outcome respectively) were small ($B = 0.14$). For example a small ‘a path’ but large ‘b path’ ($B = 0.60$) is suggested to require n = 365. All data collection procedures received ethical approval from the Western Sydney University Human Research Ethics Committee. Written informed consent was received from all participants prior to proceeding with data collection. Participants were eligible for the study if they were between the ages of 18 and 65 years, had pain and/or impairment attributed to the low back > 3-months, with symptoms reported between T12 to the gluteal folds that was not from a specific origin (as confirmed from previous back surgical history, spondylolisthesis, spinal stenosis, persistent referred pain symptoms into the lower leg). Other exclusion criteria included any surgery in the last 3 months, pregnancy in the last 12-months, diagnosed psychiatric or somatoform disorder, or any other neuromuscular or metabolic disease.

Assessment

All information for this study was collected from participants at an in-person meeting that included: duration of pain and disability symptoms (months or years), age, height, weight, and employment status over the last 3-months. Further information collected related to activities pursued in the last month for management of their back pain including medication use, consultation with an allied health professional (e.g. physiotherapist, chiropractor, clinical exercise

Table 1. Baseline characteristics of study participants (n = 218) and the sub-groups of people identified as reporting weekly physical activity (PA) or no PA. Unless otherwise stated all data are mean ± SD. The types of physical activity and number of participants reporting weekly performance of the activity type are provided. Some participants reported multiple types of activity, thus there is some overlap.

	n = 218	PA, n = 68	No PA, n = 150
Age (years)	36.2 ± 6.6	35.6 ± 7.0	36.5 ± 6.4
Female (%)	59.6	73.5	34.7
Duration of symptoms (years)	10.9 ± 7.4	10.2 ± 7.5	11.2 ± 7.4
Height (m)	1.71 ± 0.08	1.69 ± 0.07	1.71 ± 0.09
Weight (kg)	82.0 ± 14.5	78.3 ± 13.0	83.6 ± 15.0
Paid work (%)	68.3	54.4	74.7
Medication for back pain, last month (%)	29.8	19.1	34.7
Regular physical activity (%)	31.1		
• Cardiorespiratory, n		30	-
• Trunk strengthening/stabilization exercise, n		35	-
• Flexibility exercise, n		8	-
• Leisure time sport & recreation, n		6	-
• Resistance exercise, n		1	-
Oswestry disability index (ODI, 0–100%)	24.9 ± 13.6	17.6 ± 10.7	28.2 ± 13.5
Pain intensity—current (VAS-c, 0–10 cm)	3.6 ± 2.3	2.6 ± 2.1	4.1 ± 2.3
Pain intensity—worst last week (VAS-w, 0–10 cm)	5.5 ± 2.6	4.3 ± 2.6	6.0 ± 2.4
Anxiety (HADS-a, 0–21)	6.0 ± 3.4	5.4 ± 3.4	6.3 ± 3.4
Depression (HADS-d, 0–21)	4.1 ± 3.7	3.2 ± 2.8	4.5 ± 4.0
Catastrophizing (PCS, 0–52)	15.6 ± 12.6	9.9 ± 10.6	18.2 ± 12.6
Fear-avoidance—physical (FABQ, 0–24)	13.8 ± 5.6	11.8 ± 5.7	14.8 ± 5.3
Fear-avoidance—work (FABQ, 0–42)	11.3 ± 9.8	10.6 ± 9.7	11.5 ± 5.3

physiologist) or other types of treatment (e.g. remedial massage, acupuncture). We also collected information about the frequency, intensity, type, and time of physical activities performed in the last month.

Individuals were classified as performing regular structured physical activity if they described on average once per week for > 30-minutes (in one bout or accumulated over a day) an activity classified at least moderate intensity ($\geq$ 4–6 METs) defined by the American College of Sports Medicine (e.g. walking approximately $5.km.h^{-1}$ or other cardiorespiratory exercise, mowing lawns [18]), activity prescribed by an allied health professional for their back pain (e.g. trunk focussed exercise, stretching), leisure time sport or other recreational pursuits (e.g. golf without a cart), or self-directed physical activity such as resistance exercise.

Self-report questionnaires were subsequently administered at the in-person meeting comprising measures to examine pathways within the fear-avoidance model.

Disability

Self-perceived disability was measured with the Oswestry Low Back Pain Disability Index (ODI) [19]. The ODI is a 10-item questionnaire regarding how a patient's low back pain affects different aspects of their life such as walking, sitting, standing, and lifting. Each item has 6 corresponding answers that are scored in severity from 0 to 5. The scores from the 10-items are summed (maximum total of 50), and expressed as a percentage (0 to 100%). Studies have shown the ODI to have good construct validity [20], internal consistency and reliability [21].

Self-rated low back pain

A 10-cm VAS with "no pain" on the left side and "worst pain" on the right side was used to measure the current pain intensity (VAS-c), and worst pain intensity in the last week (VAS-w) [22]. The VAS has been found to have good construct validity [23] and reliability [24].

Fear-avoidance beliefs

The Fear Avoidance Beliefs Questionnaire (FABQ) was used to examine patient's beliefs about the potential harm of work or general physical activity to their back pain [25]. The FABQ has 16 items, each scored from 0 to 6. Higher numbers indicate increased levels of fear-avoidance beliefs. Two subscales within the FABQ have been identified, a 7-item work subscale score (FABQ-w, score range 0–42), and a 4-item physical activity subscale score (FABQ-p, score range 0–24). The internal consistency and test-retest reliability of the FABQ are high [26].

Pain catastrophizing

The Pain Catastrophizing Scale (PCS) was used [27]. The PCS is a 13-item questionnaire developed to identify catastrophic thoughts or feelings in relation to painful experiences. The total score ranges from 0 to 52 and high scores indicate that more catastrophic thoughts or feelings are experienced. The internal consistency and test-retest reliability of the PCS are high [28,29].

Anxiety and depression

Anxiety and depression was measured using the 14-item Hospital Anxiety and Depression Scale (HADS). There are 7-items each for anxiety and depression, with items scored from 0 to 3; higher scores indicate greater anxiety (HADS-a) or depression (HADS-d). The total score for each sub-scale ranges from 0 to 21 [30]. The HADS has good internal consistency [31], reliability [31], and validity [32,33].

Data analysis

Multiple mediation analysis was performed according to recommended procedures [34–37] to examine whether the relationship between pain and disability was explained by fear, catastrophizing, depression, and anxiety. Highly correlated variables that indicate multicollinearity ($r > 0.90$), or variables that were not correlated with either pain or disability, were excluded from the subsequent mediation analyses based on recommendations for multivariate analyses [38]. Multicollinearity between pain, disability, fear, catastrophizing, depression, and anxiety was assessed by performing Pearson correlations (Table 2).

The following a priori steps had to be successfully met to confirm mediation: 1) pain was significantly associated with disability (total effect; c path, Fig 1); 2) pain was significantly associated with each of the proposed mediator variables (fear, catastrophizing, anxiety, depression; a paths), 3) controlling for pain, each of the proposed mediators was significantly associated with disability (b paths), and 4) the relationship between pain and disability was reduced (direct effect, c' path) when controlling for the proposed mediators (indirect effect, a x b), with the 95% confidence interval (CI) for the indirect effect of each proposed mediating variable outside 0 (Fig 1).

A custom written macro (PROCESS; www.processmacro.org) was downloaded into SPSS (v22, IBM, USA) based on recommendations for how to perform multiple mediation pathway analysis with bias-corrected bootstrapping tests [34–36]. Bootstrapping is a statistical method that involves drawing repeated samples from the data with replacement in order to gain multiple estimates of the indirect effect attributed to potential mediator variables [36]. Advantages

Table 2. Correlations (r-value) between measure of disability (ODI) and pain (VAS-c, VAS-w) with depression (HADS-d), anxiety (HADS-a), fear (FABQ-a, FABQ-w), and catastrophizing (PCS).

	ODI	VAS-c	VAS-w	HADS-d	HADS-a	FABQ-a	FABQ-w	PCS
ODI	1.0	.514**	.457**	.406**	.267**	.458**	.213**	.570**
VAS-c		1.0	.680**	.260**	.137*	.292**	.243**	.580**
VAS-w			1.0	.192**	.123	.315**	.150*	.474**
HADS-d				1.0	.579**	.089	.357**	.538**
HADS-a					1.0	.009	.223**	.374**
FABQ-a						1.0	.128	.347**
FABQ-w							1.0	.242**
PCS								1.0

** is p<0.01, and
* is p<0.05.

to using this statistical approach for testing mediation over Baron and Kenny's 4-step method [39] is that it does not make the assumption of normality for the direct effects, and multiple mediators can be tested simultaneously [35,36]. Furthermore, type I error is reduced because fewer statistical tests are required [36].

Two mediation analyses were performed (PROCESS, model 4) to examine whether the proposed mediators influenced the relationship between VAS-c and VAS-w with ODI. Further analyses were performed (model 4) to examine whether PCS mediated the relationship between VAS scores and fear (FABQ-a, FABQ-w).

We tested for moderated mediation of the entire FABQ model using PROCESS model 15. First, the conditional indirect effects (a x b path) for each mediator variable were compared between individuals who did and did not report performance of a structured weekly physical

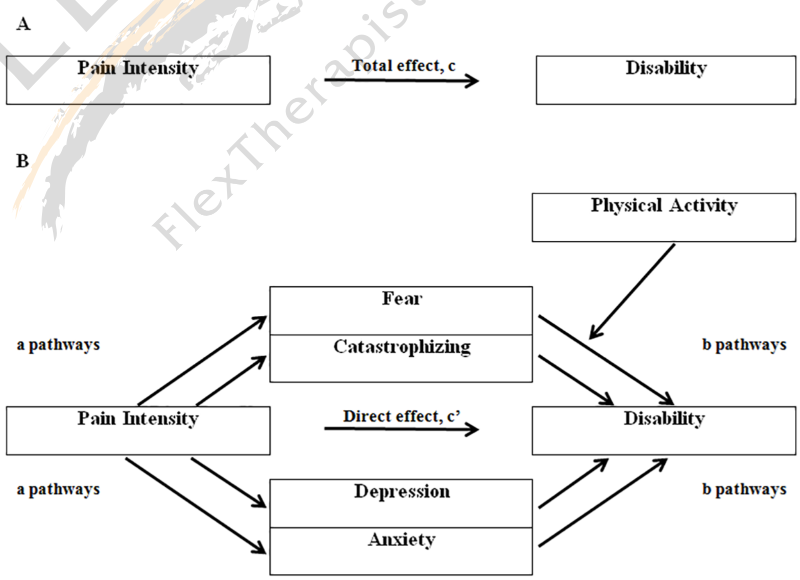


Fig 1. Example of the mediation-moderation model tested in this study. (A) is the primary relationship between pain and disability, with the total effect labelled c. (B) are the proposed mechanisms of mediation and moderation. The direct effect (c') is the effect of pain on disability after controlling for the mediator variables. The indirect effect of pain on the mediators are the 'a pathways'. The indirect effect of the mediators on disability are the 'b pathways'.

Table 3. Total effect, direct effect, indirect effect, and r^2 values for the mediation models of current pain (VAS-c) and worst pain in the last week (VAS-w) with disability (ODI).

Model	Path	*B*	95% CI	SE	t score	p-value	Model r^2
VAS-c to ODI	Total effect (c)	3.02	2.35 to 3.70	0.34	8.82	<0.001	0.26
	Direct effect (c')	1.51	0.79 to 2.24	0.37	4.09	<0.001	
	Indirect effect (a x b)	1.50	0.88 to 2.16	0.33			
VAS-w to ODI	Total effect (c)	2.42	1.79 to 3.06	0.32	7.55	<0.001	0.21
	Direct effect (c')	1.07	0.45 to 1.68	0.31	3.43	<0.001	
	Indirect effect (a x b)	1.36	0.92 to 1.92	0.25			

activity session using bias-corrected bootstrapping (5,000 resamples). If 95% confidence intervals for the between-group contrast did not include 0 the separate indirect effects for each variable were inspected to determine which physical activity group influenced mediation outcomes. All regression coefficients are presented as the unstandardized regression coefficients (*B*) from the PROCESS macro. The significance level of this study was $p \leq 0.05$.

Results

Relationship between variables

All correlation coefficients were below 0.90 indicating that multicollinearity was not present (Table 2). ODI and VAS-c were associated with all variables, and VAS-w was associated with all variables apart from HADS-a. Therefore the only variable excluded from mediation analyses was for HADS-a in the relationship between VAS-w and ODI.

Mediation of the relationship between pain and disability

The mediation analyses (Tables 3 and 4) revealed similar outcomes for current pain intensity (VAS-c) and worst pain in the last week (VAS-w), therefore only the VAS-c result will be clarified further. The overall regression model showed that 46.9% ($p<0.001$) of the variance in ODI scores was explained by VAS-c and the mediator variables. The relationship between pain (VAS-c) and disabilty (ODI) was significant (total effect, c pathway, $B = 3.02$, $r^2 = 0.26$, $p<0.001$). The overall indirect effect for the multiple mediator model was $B = 1.50$ (95% CI = 0.88 to 2.16), and accounted for 49.7% of the total effect. Indirect effects for the proposed

Table 4. Indirect paths of the multiple mediator model for fear (FABQ-a, FABQ-w), catastrophizing (PCS), depression (HADS-d), and anxiety (HADS-a). 95% confidence intervals for the indirect effect were calculated using bias-corrected bootstrapping with 5,000 resamples.

	a Path (pain on mediator)				b path (mediator on disability)				Indirect effect (a x b path)		
	B	SE	t score	p-value	*B*	SE	t score	p-value	*B*	SE	95% CI
VAS-c to ODI											
FABQ-a	0.71	0.16	4.49	<0.001	0.72	0.13	5.43	<0.001	0.51	0.15	0.25 to 0.85
FABQ-w	1.03	0.28	3.68	<0.001	-0.02	0.08	-0.21	0.832	-0.01	0.08	-0.22 to 0.12
PCS	3.14	0.30	10.45	<0.001	0.22	0.08	2.80	0.006	0.70	0.30	0.11 to 1.34
HADS-a	0.20	0.10	2.03	0.043	0.21	0.25	0.85	0.399	0.04	0.06	-0.05 to 0.21
HADS-d	0.42	0.11	3.96	<0.001	0.64	0.26	2.48	0.014	0.27	0.16	0.02 to 0.65
VAS-w to ODI											
FABQ-a	0.69	0.14	4.87	<0.001	0.70	0.14	5.12	<0.001	0.48	0.13	0.25 to 0.75
FABQ-w	0.57	0.26	2.23	0.027	0.02	0.08	0.22	0.823	0.01	0.05	-0.08 to 0.11
PCS	2.32	0.29	7.91	<0.001	0.29	0.08	3.79	<0.001	0.67	0.21	0.29 to 1.13
HADS-d	0.28	0.10	2.88	0.004	0.63	0.26	2.43	0.016	0.18	0.12	0.02 to 0.49

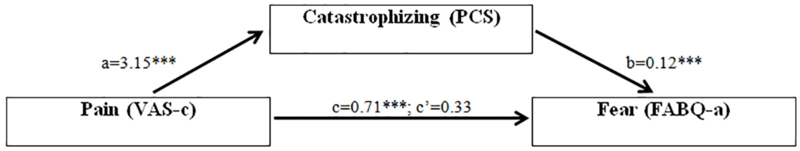


Fig 2. Mediation of the relationship between pain and fear through catastrophizing. Coefficients for the different pathways (a, b, c) are displayed. The indirect effect (a x b pathway) for PCS was 0.37 (95% CI 0.15 to 0.62). *** is p<0.001.

mediators are depicted in Table 4. Only FABQ-a, PCS, and HADS-d met all criteria for significant mediation of the relationship between pain and disability. Overall, 42.4% of the variability in the relationship between pain and disability was explained by FABQ-a, PCS, and HADS-d.

Catastrophizing as a mediator of the relationship between pain and fear

Because of the similarity in outcomes between VAS-c and VAS-w (Tables 3 and 4), and that only FABQ-a was a significant mediator of the relationship between pain and disability (Table 4), we only tested whether PCS mediated the significant relationship between VAS-c and FABQ-a ($B = 0.71$, $r^2 = 0.09$, $p<0.001$). All criteria for significant mediation were met (Fig 2), with the indirect effect of PCS ($B = 0.37$, 95% CI 0.15 to 0.62) explaining 53% of the total effect of VAS-c on FABQ-a.

Physical activity moderates the effect of catastrophizing

The indirect effect of catastrophizing on the relationship between VAS-c and ODI was significantly moderated by reporting of weekly structured physical activity (Table 5). Specifically, the indirect effect for PCS mediating the relationship between VAS-c and ODI was only significant for individuals reporting weekly physical activity ($B = 1.31$, 95% CI 0.44 to 2.23), compared to individuals reporting no weekly physical activity ($B = 0.21$, 95% CI -0.50 to 0.97).

The conditional indirect effects for PCS mediating the relationship between VAS-c and FABQ-a were not different between individuals who did and did not report weekly physical activity ($B = 0.37$, 95% CI -0.17 to 0.94).

Table 5. Test of equality between the moderated indirect effects (a x b pathway) for patients with low back pain who did and did not report weekly physical activity, using bias-corrected bootstrapping (5,000 resamples).

	B	SE	95% CI
VAS-c to ODI			
FABQ-a	0.24	0.21	-0.11 to 0.73
FABQ-w	-0.09	0.16	-0.45 to 0.22
PCS	-1.10	0.57	-2.31 to -0.32
HADS-a	0.03	0.10	-0.14 to 0.28
HADS-d	0.32	0.26	-0.11 to 0.92
VAS-w to ODI			
FABQ-a	0.18	0.18	-0.12 to 0.59
FABQ-w	-0.05	0.10	-0.28 to 0.10
PCS	-0.63	0.39	-1.48 to 0.11
HADS-d	0.21	0.17	-0.03 to 0.64

Discussion

Summary of main findings

We conducted this study to investigate proposed pathways within the fear-avoidance model in a relatively large sample (n = 218) of chronic low back pain patients, and to address gaps in the literature pertaining to the potential mediating effect of catastrophizing on the pain-disability relationship. Moreover this was the first study to examine the moderating effect of physical activity on pathways within the fear-avoidance model. The main findings of this study were 1) fear, catastrophizing, and depression explained 42.4% of the relationship between pain and disability in patients with chronic low back pain, 2) the mediating effect of catastrophizing was conditional upon the performance of weekly structured physical activity, and 3) catastrophizing mediated the relationship between pain and fear, the first proposed pathway in the fear-avoidance model, and this was not conditional upon the performance of regular physical activity.

Fear-avoidance

The results of this study support previous findings for the role of fear-avoidance and depression as significant mediators of the positive relationship between pain and disability in chronic back pain patients [11]. Thus the relationship between higher pain and disability is, in part, explained by higher self-rated fear-avoidance beliefs about physical activity and depression. A novel finding of this study was that the mediating effect of fear was not conditional upon physical activity. This provides insight into the confusing findings with regards to changes in fear-avoidance following physical activity interventions. While some studies have reported small-to-medium effect sizes for reductions in fear following physical activity or exercise interventions for back pain [40–43], a number of studies have shown no change in measures of fear-avoidance despite reduced pain and disability [44–48]. These equivocal findings lead to confusion for evidence-based practitioners attempting to understand why a physical activity based intervention may or may not be effective for reducing fear-avoidance beliefs in chronic back pain patients. Recent evidence suggests that physical activity interventions are only effective for reducing high fear-avoidance beliefs when combined with cognitive behavioural approaches [49,50]. The results of this study provide support for the need to supplement physical activity interventions with cognitive approaches, because the mediating effect of fear on pain related disability was not conditional upon performing weekly structured physical activity. In other words, performing exercise alone is likely not sufficient to reduce fear of movement and therefore pain related disability in people with chronic low back pain.

Catastrophizing

We have also extended current understanding for the role of catastrophizing as a mediator of the relationship between pain and disability in chronic back pain patients. Catastrophizing is defined as an exaggerated negative interpretation of pain that may occur during an actual or anticipated pain experience [27]. There are equivocal results for the association between catastrophizing and pain related disability in back pain patients [9,51–54], and for catastrophizing as a factor to explain successful outcomes in back pain patients following different types of treatment [13,47,55,56]. The pooled coefficient from the recent meta-analysis [11] for the indirect effect (a x b pathway) of catastrophizing as a mediator of the pain-disability relationship was not significant ($B = 0.07$, 95% CI -0.06 to 0.19), although based on a relatively small sample (3 studies, n = 234 patients) and inclusive of both acute and chronic back pain patients. Our analyses of 218 people with chronic back pain revealed that the indirect effect of catastrophizing, but not fear or depression, was conditional upon reporting engagement with weekly structured physical activity (conditional a x b pathway; $B = 1.31$, 95% CI 0.44 to 2.23). Thus in people with chronic back pain who reported weekly physical activity, albeit within our definition of physical activity, higher catastrophizing scores in addition to fear and depression explained the relationship between pain and disability. Catastrophizing had no influence on the pain-disability relationship for chronic back pain patients who reported no weekly structured physical activity, with an indirect effect comparable to previous data ($B = 0.21$, 95% CI -0.50 to 0.97). Therefore a unique and important recommendation for clinical practice is that people with chronic back pain who regularly engage with, or potentially initiate regular physical activity, may require specific psychological counselling or support with regards to negative perceptions about pain. Because this was a cross-sectional study, the temporal relationship between performing regular physical activity and negative pain perceptions are unclear.

The second objective of this study was to examine the proposed pathway of the fear-avoidance model where catastrophizing mediates the relationship between pain and fear. To our knowledge, we are the first to report that catastrophizing is a significant, positive mediator of the relationship between pain and fear in chronic low back pain patients, and that this relationship is not conditional on physical activity. While significant, the relationship between pain and fear was relatively small ($r^2 = 0.09$). Therefore the relative importance of this pathway should be questioned. Indeed two prospective studies [57,58] showed that early changes in catastrophizing after injury or following early engagement with a treatment provider for musculoskeletal pain do not precede changes in fear, or predict changes in disability or depression. Therefore while a statistically significant finding, the clinical relevance of catastrophizing as a mediator of the relationship between fear and pain seems limited.

Implications for practice

Recently the fear-avoidance model has been critiqued for both the lack of empirical support for proposed pathways, or consideration for how multi-dimensional processes (e.g. social, cultural, environmental factors) influence relationships [59]. For clinicians, the relative importance of the fear-avoidance model is often discussed, but translating research into effective treatment for people with chronic low back pain is lacking. Our findings are novel because they show that an external condition, in this case performance of weekly structured physical activity, explains relationships between proposed belief pathways in the fear-avoidance model. Indeed a strength of our data analysis is that mediation is often thought to reveal specific variables to be targeted with interventions, such as fear and depression. Our data supports current recommendations that psychological counselling with regards to fear and depression should be a standard treatment inclusion for people with chronic low back pain [11,49].

The results of our study also provide unique clinical perspectives with regards to the relationship between regular physical activity, catastrophizing, and fear-avoidance. First, people with chronic low back pain who engage with weekly physical activity appear to require additional support to address negative pain perceptions. What this support entails is unclear from the current study, although education about chronic pain (e.g. [49]) as compared to the feelings of discomfort elicited from normal physical activity is a likely first step. Second, it appears that engagement with regular physical activity is not necessary to influence the mediating effect of fear-avoidance beliefs on the pain-disability relationship. While physical activity interventions have tremendous benefits for overall health and are frequently prescribed in chronic back pain, the overall effect size for these interventions on back pain related disability is small-to-medium [60,61]. Our data suggest that greater emphasis may need to be placed on the psychosocial components of pain to complement and improve the response to physical activity interventions.

Limitations

There are several limitations that should be considered. The definition of weekly physical activity was based on the self-report of at least one session per week for the last month consisting of either cardiorespiratory type exercise, trunk exercise (self- or therapist-directed), or other forms of physical activity. This definition does not quantify physical activity in terms of gross caloric expenditure, nor provide activity 'dose' information. Quantification of physical activity based on accelerometer data would not accurately capture exercise routinely performed by back pain patients, such as a trunk stability program that involves minimal whole body movement (i.e. accelerations). We did not elect to categorize physical activity based on a higher threshold, such as three times per week, based on the current low back pain rehabilitation literature where one session per week appears equitable to a minimum level likely to have positive outcomes for patients [60]. Nor did we want to compare different types of exercise, since the overwhelming evidence is that no one mode of exercise is superior to any other for chronic back pain rehabilitation [60].

With regards to the mediation analyses conducted in this study, the explanatory factors of fear, depression, and catastrophizing did not completely mediate the relationship between pain and disability. There are likely other behavioural factors, such as self-efficacy, that contribute to this relationship [11]. However, the scope of this study was with regards to pathways described within the fear-avoidance model. While ongoing discussion in the literature attempts to refine and update this model, we did not measure variables that as yet are not typically included within the fear-avoidance pathways.

The results of this study should not be generalized to all back pain patients. In particular fear about work related activities, as well as depression and anxiety scores, were lower than reported in other studies of chronic back pain patients. These lower scores may, in part, explain why FABQ-w and HADS-a scores were not identified as significant mediators. However, we believe our sample is representative of the typical patient who chooses to engage with treatment. Indeed scores for disability, pain, and fear about physical activity were similar to baseline values for recent clinical trials [47,49]. Thus our findings likely have good generalizability for clinical practice.

Based on estimates for required sample sizes in mediation analyses [17], our study was not sufficiently powered to detect significant indirect effects when the a and b paths (exposure to mediator, mediator to outcome respectively) were small ($B = 0.14$). For example a small 'a path' but large 'b path' ($B = 0.60$) is suggested to require n = 365. Inspection of our data (Table 4) would suggest that we were only underpowered to detect a significant indirect effect for anxiety (HADS-a) mediating the relationship between current pain and disability. However, further exploration of these pathways is needed.

Finally, while we designed this study to address many of the quality recommendations for mediation analyses (e.g. a theoretical framework, sample size justification, accurate pathway analysis and inspection of indirect effects, [11]), we were unable to address temporal causality for relationships between the respective variables (i.e. physical activity and catastrophizing). This study was a cross-sectional examination of participants with chronic low back pain from the local community who attended the University research facility for different experimental studies. Therefore no inferences can be made about whether changes in one variable precede another.

Conclusion

This study found that fear, depression, and catastrophizing mediate the relationship between pain and disability in people with chronic low back pain. The mediating effect of catastrophizing, but not fear or depression, was conditional upon participants reporting weekly performance of structured physical activity sessions. Thus chronic back pain patients who engage with regular physical activity may require psychological intervention and support for negative perceptions of pain. The effect of fear and depression on pain related disability was not related to regular physical activity, suggesting that psychological interventions are likely the best treatment choice for these factors.