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Evidence for a direct relationship between cognitive and physical change during an education intervention in people with chronic low back pain

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Abstract

Background. Unhelpful pain cognitions of patients with chronic low back pain (LBP) may limit physical performance and undermine physical assessment. It is not known whether a direct relationship exists between pain cognitions and physical performance.

Aims. To determine if a relationship exists between change in pain cognitions and change in physical performance when chronic LBP patients participate in a single one-to-one education intervention during which they have no opportunity to be active.

Methods. In a quasi-experiment using a convenience sample, moderately disabled chronic LBP patients ($n = 121$) participated in a one-to-one education session about either lumbar spine physiology or pain physiology. Multiple regression analysis evaluated the relationship between change in pain cognitions measured by the survey of pain attitudes (SOPA) and the pain catastrophising scale (PCS) and change in physical performance, measured by the straight leg raise (SLR) and standing forward bending range.

Results. There was a strong relationship between cognitive change and change in straight leg raise (SLR) and forward bending ($r = 0.88$ and 0.79, respectively, $P < 0.01$), mostly explained by change in the conviction that pain means tissue damage and catastrophising.

Conclusions. Change in pain cognitions is associated with change in physical performance, even when there is no opportunity to be physically active. Unhelpful pain cognitions should be considered when interpreting physical assessments.
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Keywords: Chronic pain; Cognitions; Education; Physical assessment; Pain attitudes

1. Introduction

In patients with chronic pain, the relationship between pain and physical performance is not well understood, although cognitive and behavioural factors appear to be important. The development of the cognitive–behavioural approach to rehabilitation has led to multidisciplinary pain management programs that promote physical improvement by changing the patients' cognitive and behavioural response to their pain. Cognitive intervention targets unhelpful pain cognitions and beliefs including fear-avoidance beliefs, catastrophic thought processes, and the belief that pain is necessarily indicative of tissue damage (Tota-Faucette et al., 1993; Williams et al., 1993; Newton-John et al., 1995). There is wide variability in the nature, mode and context of these programs, and debate exists as to the efficacy of different approaches. However, intensive (full-time) inpatient multidisciplinary programs based on a cognitive–behavioural approach have reported increased physical and functional performance, at least in people with chronic non-specific low back pain (LBP) (McQuay et al., 1997; Morley et al., 1999). It is thought that by implementing a combination of psychological and physical strategies, these programs promote improved physical performance via increased exposure to activity instigated by cognitive and behavioural change. That is, an indirect relationship between reduction of unhelpful

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pain cognitions and increase in physical performance is implied. Another possibility is that pain cognitions are directly related to physical performance. If so, normalisation of pain cognitions may be associated with improved physical performance even before the patient is exposed to physical activity or training.

There are some studies that have alluded to a direct relationship between cognitive and physical change effected by pain management strategies. Most studies have linked pain cognitions to disability (e.g., Stroud et al., 2000) or maximal strength (e.g., Keller et al., 1999) measures. These measures are influenced by many factors, which make it difficult to directly relate physical change to cognitive change. One study, which investigated muscle activity in chronic LBP patients during forward bending and controlled for the speed and range of the movement, concluded that the pattern of paraspinal muscle activity was related to self-efficacy and fear-avoidance beliefs (Watson et al., 1997). That experimental design minimised voluntary modification of the task, which strengthens the authors' conclusion. Those authors then demonstrated that the pattern of paraspinal muscle activity was normalised after a multidisciplinary pain management program and that a relationship existed between cognitive and physical performance change. This finding is consistent with other work that observed a link between cognitive and physical change after a cognitive and physical program (Alaranta et al., 1994; McCracken and Gross, 1998).

Studies such as those observe that patients are likely to improve in both cognitive and physical aspects. However, they do not assess the direct relationship between variables, improvements may be mediated by different aspects of the management program. Although it is possible to delineate the impact of various components of treatment, in order to directly address the relationship between cognitive and physical variables, it would be optimal to intervene in a manner that did not involve both physical and cognitive components. Further, because cognitive factors are invariably involved during physical interventions, it would seem necessary to intervene in a manner that did not permit exposure to physical activity. This is difficult in pain management programs because they invariably are multidimensional in nature.

Education is an intervention that promotes cognitive change without (necessarily) involving physical exposure. In a recent randomised controlled trial, it was demonstrated that a one-to-one education session, which provided information about the neurophysiology of pain and nociception, resulted in significant change in pain attitudes and beliefs (Moseley et al., 2002). That study was based on the notion that reconceptualisation of the problem would promote altered attitudes and beliefs. Based on that work, it was anticipated that a one-to-one education session may provide an accessible model with which to investigate the relationship between cognitive and physical change in patients with chronic LBP.

Thus the aim of this study was to use a non-physical education intervention to explicitly address the relationship between change in pain attitudes and beliefs, and change in physical performance. Two types of education material were used to increase the likelihood of between subject variation in response.

2. Methods

2.1. Experimental design

The present study was a quasi-experiment, in which a convenience sample was used. The first 86 subjects were allocated, using a coin toss, to receive one of two types of educational material. A further 35 subjects were allocated to one type of material because the available data indicated that the other material was associated with unfavourable outcomes. As this study did not aim to compare the two groups, it was not considered necessary to randomise subjects. Assessments were performed by two separate investigators who remained blinded to treatment group and to assessment time.

2.2. Participants

Patients who consulted private rehabilitation clinics or physiotherapy centres over a period of 3 years with a history of CLBP of greater than 4 months were advised of the project via direct approach from the treating therapist, who was not an investigator ($n = 156$). Volunteer subjects ($n = 150$) were excluded if they had; worsening neural signs, for example increasing loss of sensory or motor function ($n = 5$), an inability to understand, read and speak English ($n = 18$) or they had previously participated in a back school or multidisciplinary pain management program ($n = 6$). Aside from these interventions, the type of information previously provided to subjects was not assessed. Informed written consent was obtained and the study was approved by the institutional ethics committee and complied with the Declaration of Helsinki. The present study was conducted before normal physiotherapy assessment and intervention was undertaken.

Subject characteristics are shown in Table 1.

2.3. Intervention procedure

All subjects participated in a single one-to-one education session with a trained physiotherapist, who was not otherwise involved in the study and not involved in assessment. Two types of information were presented

Table 1
Subject characteristics

	Pain physiology education ($n = 75$)	Lumbar spine physiology ($n = 46$)
Age (years)	36 ± 6	35 ± 7
Height (cm)	170 ± 8	175 ± 12
Weight (kg)	75 ± 5	71 ± 4
RMDQ	12.5 ± 4	12.0 ± 3
VAS pain intensity	5.5 ± 3	5.0 ± 3
Female	50%	65%
Normal work or home duties	20%	28%
Reduced work or home duties	36%	30%
Not working or minimal home duties	44%	42%
Years of formal education	9 ± 5	9 ± 4
Duration of pain (years)	3.9 ± 1.7	3.3 ± 1.2
SOPA 1 pre (post)	14 ± 4 (14 ± 3)	13 ± 4 (12 ± 4)
SOPA 2 pre (post)	8 ± 5 (10 ± 4)	8 ± 4 (8 ± 5)
SOPA 3 pre (post)	7 ± 4 (8 ± 5)	7 ± 5 (7 ± 5)
SOPA 4 pre (post)	11 ± 4 (9 ± 5)	12 ± 5 (12 ± 4)
SOPA 6 pre (post)	12 ± 4 (10 ± 3)	12 ± 5 (13 ± 4)
PCS pre (post)	16 ± 6 (13 ± 5)	16 ± 5 (17 ± 5)
SLR pre (post)	41 ± 12 (46 ± 13)	40 ± 10 (41 ± 12)
Forward bending cm from floor pre (post)	18 ± 15 (15 ± 14)	20 ± 14 (22 ± 15)

Mean ± SD for demographic variables, perceived disability (Roland Morris Disability Questionnaire, RMDQ), mean pain intensity over the last 48 h (visual analogue scale, VAS). Pre- and post-intervention scores for the subfactors of the survey of pain attitudes, SOPA; the pain catastrophising scale, PCS; straight leg raise, SLR and forward bending range are also shown. There were no pre-treatment differences between groups.

such that subjects learnt about either the physiology of pain and nociception or the anatomy and physiology of the lumbar spine. The provision of information in this manner is based on the assumption that the provision of currently accurate information promotes reconceptualisation of the problem of chronic LBP. There are emerging data that suggest that this assumption is valid in that intervention has been shown to affect pain cognitions (Moseley et al., 2002) and, when combined with physiotherapy, reduce pain and disability (Moseley, 2002). An outline of the type of material that was presented in each group is shown in Table 2. The material provided for the pain physiology education is presented in Butler and Moseley (2003). For both groups, the education session was conducted in one-to-one seminar format. The session consisted of the presentation of information only using hand-drawn and prepared pictures with an interactive commentary. There were no problem solving, skills training or role-playing exercises. Hypothetical examples were used to convey concepts. The education session lasted ~3 h.

2.4. Measurement procedures

The following assessments were conducted before and after education such that time between assessments was 3.5 h. After the final assessment, using a visual analogue scale anchored with "very differently" and "exactly the same", subjects were asked "How similarly did you perform the tasks that time?" A further follow-up was not conducted because the aim was to evaluate cognitive and physical change when exposure to physical activity was not possible.

2.5. Questionnaires

Based on pilot trials, two questionnaires were selected because they appeared most likely to be sensitive to

Table 2
Outline of material that was presented to the two groups

Neurophysiology of nociception and pain	*Anatomy and physiology of the lumbar spine*
The neuron: receptor, axon, terminal	The intervertebral disc: structure and physiology, effects of aging
The synapse: neurotransmitters, chemically driven ion channel, post-synaptic membrane potential, action potential	Vertebral canal and intervertebral foramen: thecal sac, spinal nerve root, ligamentum flavum
Spinal and descending inhibition and facilitation	The facet joint: anatomy and biomechanics
Peripheral sensitisation	The muscles: anatomy, physiology, antagonist, agonist and synergistic roles
Central sensitisation: potentiation of the post-synaptic membrane, altered genetic expression, receptor field growth	Spinal biomechanics: curvatures, posture, ergonomics

change imparted by one-to-one education. The brief survey of pain attitudes (SOPA(R) (Strong et al., 1992) was included as a sensitive and valid measure of attitudes and beliefs about pain, was used to evaluate beliefs and attitudes about pain. This tool does not evaluate concepts of pain physiology but includes items such as "Chronic pain means something is wrong with the body, which prevents much movement or exercise" and "Exercise can decrease the amount of pain I experience".

The pain catastrophising scale (PCS) (Sullivan et al., 1995). The PCS is a self-report questionnaire that assesses unhelpful coping strategies and catastrophic thinking about pain and injury and has strong construct validity, reliability and stability (Sullivan et al., 1995). Example items include "I wonder whether something serious may happen" and "I keep thinking about how much it hurts". High scores, for example >10, indicate catastrophic thinking about pain.

2.6. Physical performance measures

Subjects performed two physical performance tasks, which are common clinical measures and were assessed by a separate investigator blinded to education group and treatment occasion, such that pre- and post-assessments were performed by separate therapists, but randomised between them. The inter-rater reliability for these tests has been verified (Moseley, 2001).

2.6.1. Straight leg raise

The left foot of the supine subject was placed in a thermoplastic heel brace maintaining a fixed angle between the foot and the shin. The brace was used to raise the leg until the subject reported onset of pain (if there was no pain at rest), or an increase in pain (if there was resting pain), in the leg or low back. A maximum range inclinometer fixed to the heel brace measured the range of the SLR. The SLR is limited by verbal feedback from the subject or volitional motor activity and its use has been documented widely (e.g., Hultman et al., 1992; Li et al., 1996; Martinez et al., 1997).

2.6.2. Forward bending range

In relaxed standing and feet shoulder-width apart, the subject was instructed to bend forward keeping the knees straight and to "go as far as you can without bending your knees". No other instructions were given. If the knees bent, the test was repeated. The distance from the longest finger to the floor at full range of forward flexion range was measured and recorded. If the fingers reached the floor, the distance was recorded as zero. Forward bending provides a repeatable measure of physical performance (Moseley, 2001). It can be limited voluntarily or by tissue resistance. The contribution of different anatomical segments to the range of movement was not considered important for the current work.

2.7. Data analysis

The SOPA(R) was analysed according to the five-factor structure reported by Strong et al. (1992), which estimated attitudes about (1) seeking care from others when in pain ('solicitude') (2) the effect of emotions on pain ('emotions'), (3) controlling pain ('control'), (4) the cause of pain ('harm'), and (6) the relationship between pain and disability ('disability'). Factor (5), attitude toward medication, was not included because of the poor internal consistency of this factor (Strong et al., 1992). Change in each factor of the SOPA(R) was considered positive if it occurred in the same direction as that targeted in pain management programs: an increase in emotions and control and a decrease in solicitude, harm and disability. A single total score was obtained for the PCS.

A multiple regression was performed on the raw change in cognitive and physical performance measures, as long as the data fulfilled the main assumptions for this test; linearity and normality. Normality was tested using a Shapiro–Wilk's W test, which is the test of choice (Shapiro et al., 1968), and although linearity is difficult to unequivocally confirm, plotted data were observed for curvature as per recommendations in the literature (Statsoft, 1995). A Bonferroni correction was applied such that significance was set at $P = 0.025$.

Assessment scores obtained by the two therapists were compared using a t test and pre-treatment variables were compared using a series of t tests to minimise the probability of not detecting a difference.

Statistical analyses were performed in Statistica 5.1 (Statsoft, Tulsa, USA).

3. Results

Participants felt that they performed the physical performance tasks similarly on both occasions (mean ± SD = 9.8 ± 0.2). Summaries of the multiple regression analyses are shown in Table 3. Positive and negative change was observed in both cognitive and physical measures. A strong relationship existed between change in pain attitudes and beliefs, and SLR and forward bending. However, only the PCS and the harm and disability factors of the SOPA contributed to this effect. The cognitive variables explained ~77% and ~60% of the variance in SLR and forward bending, respectively. Tolerance (>0.6 for all) and partial correlation (<0.17 for all) statistics were considered acceptable to rule out multicollinearity of the independent variables. Fig. 1 presents the plot of actual change in physical variables versus predicted change according to the change in SOPA and PCS scores, for SLR (Fig. 1(a)) and forward bending (Fig. 1(b)).

Table 3
Regression summaries for raw change in straight leg raise (a) and forward bending (b) for the raw change in the five factors of the SOPA and the PCS

	β	$t(113)$	P
(a) $r = 0.88$, adjusted $r = 0.877$, $F(6, 113) = 68.6$, $P < 0.001$, SE = 2.99			
Solicitude	0.01	0.21	0.83
Emotions	−0.03	−0.75	0.45
Control	−0.09	−1.74	0.08
Harm	−1.2	−7.23	0.001
Disability	2.92	11.91	0.001
PCS	−1.0	−7.54	0.001
(b) $r = 0.79$, adjusted $r = 0.785$, $F(6, 113) = 32.0$, $P < 0.001$, SE = 4.55			
Solicitude	0.11	1.76	0.07
Emotions	0.09	1.49	0.13
Control	−0.10	−1.41	0.15
Harm	−1.10	−4.77	0.001
Disability	1.75	5.45	0.001
PCS	−1.40	−7.89	0.001

There were no differences between groups on the pre-intervention measures or demographic variables ($P > 0.21$). There was no difference between therapists' assessments of SLR or forward bending range ($P > 0.37$).

4. Discussion

This study shows that when LBP patients participate in an education intervention in which there is no opportunity to be physically active, there is a strong association between change in pain-related attitudes and beliefs and physical performance. This is evidenced by the finding that the change in the cognitive measures accounted for ~77% and ~60% of the variance in change in SLR and forward bending, respectively. In light of the fact that there was no opportunity to be active, the change in physical performance was not mediated by exposure to movement or activity. This finding implies, that in people who are disabled by CLBP, physical performance is directly limited by unhelpful pain cognitions.

At first glance, it is not surprising that the pain physiology education tended to impart improved physical performance. However, it is important to note that no material on pain attitudes or behavioural responses was included. This type of education aims to provide the patient with an understanding of the physiological mechanisms underlying their pain rather than a specific cognitive or behavioural response to their pain. The current data are supportive of previous work that demonstrates attitudinal changes are made in light of this information (Moseley et al., 2002). It should also be noted that positive and negative cognitive change was observed in subjects from both education groups, but the relationship with physical performance persisted.

The results of this study are generally supportive of recent proposals that cognitive factors may cause persistent changes in movement patterns, which in turn promote chronicity (Main and Watson, 1996; Watson et al., 1997). For example, Watson et al. (1997) found that during forward bending, there was a relationship between the pattern of paraspinal muscle activity and fear-avoidance and self-efficacy beliefs. When the subjects participated in a multidisciplinary pain management program, the authors found a relationship between normalisation of EMG patterns and the cognitive factors. Those authors postulated that altered cognitions allowed increased exposure to activity, which led to increased or altered performance. The current results are not explained by other models of an indirect relationship between cognitions and movement, for example the

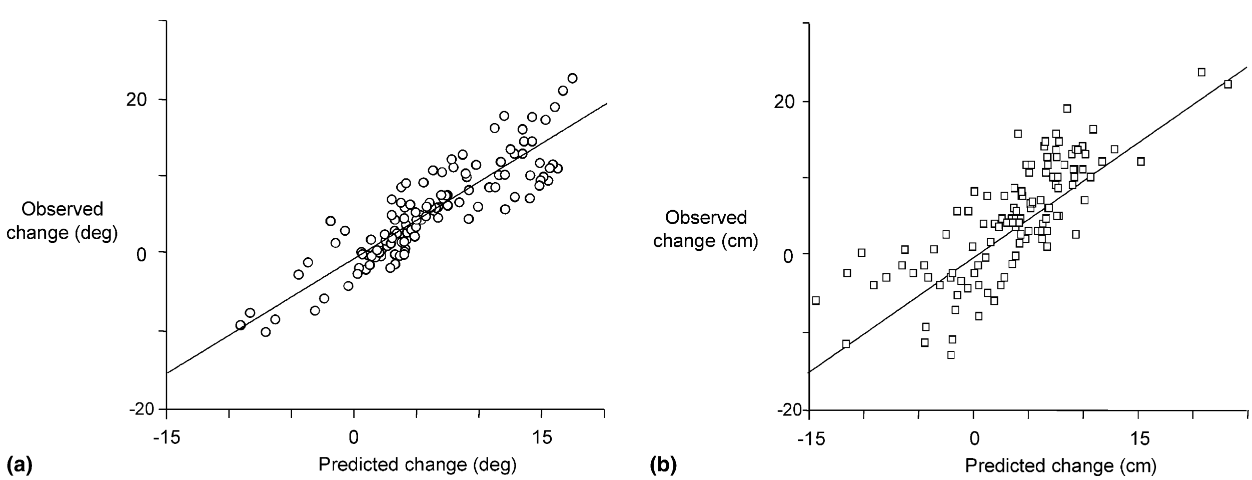

Fig. 1. Actual (y-axis) vs predicted (x-axis) scores for change in straight leg raise (SLR) (a) and forward bending (b) imparted by one-to-one education on either lumbar spine physiology of pain physiology. Predicted scores were calculated using separate multiple regression analyses, which are presented in Table 3(a) (SLR) and (b) (forward bending) and which included five subfactors of the survey of pain attitudes and the pain catastrophising scale.

muscle tension theory. That theory proposes that psychological factors cause sustained elevation of muscle tension, which in turn causes release of algogenic substances leading to peripheral sensitisation (Flor et al., 1985). Reduction in this mechanism is unlikely to explain the present results because there was insufficient time between tests. Further, it is unlikely that negative cognitive change observed in some patients would have elicited the reverse process in such a short period. While it is feasible that SLR and forward bending would be limited by elevated paraspinal muscle tension, it is more likely that subtle and perhaps complex mechanisms may be involved.

The current result that change in PCS score was associated with change in physical performance raises the possibility that an alteration in catastrophic thinking about pain was accompanied by an alteration in somatic vigilance. This proposal is based on work that demonstrated vigilance to somatic inputs in patients with chronic pain who are also catastrophisers (Flor et al., 1997; Main, 1983; McCracken et al., 1998). Altered somatic vigilance may lead to a change in pain threshold or pain tolerance (Geisser et al., 1993). Assessment of somatic perception would have permitted evaluation of this speculation. Alternatively, according to recent proposals, pain occurs when the brain considers that it will provide some biological advantage (Wall, 1999) and many authors emphasise the fundamental importance of the meaning of a nociceptive stimulus for the production of pain (Ferrell and Dean, 1995; Magid, 2000; Simkin, 2000; Jensen et al., 2001). It is plausible that altered pain cognitions changed the meaning of the nociceptive information, which in turn caused a change in the production of pain and thus performance of the task.

The current design does not demonstrate the underlying mechanisms that may have been involved. However, changes in pain-related attitudes and beliefs were observed without directly addressing these beliefs, and changes in physical performance were observed without exposure to physical activity. These findings suggest that the education promoted ‘deep learning’, at least in a portion of subjects. Deep learning is that in which information is retained and understood and applied to problems at hand (Sandberg and Barnard, 1997). In contrast, ‘superficial’ or ‘surface’ learning is that in which information is remembered but not understood or integrated with attitudes and beliefs (Evans and Honour, 1997). The notion that deep learning occurred is consistent with the theoretical justification for education of the sort used here, that is, reconceptualisation of the problem. To this effect, it is important to note that deep learning is facilitated by high motivation (Sankaran, 2001) and personalisation of the information presented (Moreno and Mayer, 2000), both of which are promoted by the method of education used here, and both of which may have had an effect on outcomes.

Change in cognitive variables explained ~70% of the variance in SLR and forward bending, which means that ~30% of the variance in each case was due to other factors. Inter-rater reliability measures of 0.77 and 0.89 for SLR and FFR, respectively, have been obtained using the protocol employed in these studies (Moseley et al., 2002), which indicates that measurement error may have contributed to the residual variance. The current work did not evaluate the effect of 3 h interval between measurements, which may have yielded a systematic effect on physical performance throughout the sample, although it is notable that for those subjects in whom a negative change was observed, the relationship between cognitive and physical variables was maintained. Finally, other testing artefacts, such as time of day and subcategory of CLBP may have affected results.

It now seems accepted that cognitive factors need to be considered in the assessment and management of CLBP. The results of this study support this view and also raise three main implications. First, it is possible that limitations of physical performance that are identified clinically may be consequent in part to unhelpful pain cognitions, and therefore may respond to strategies that effect cognitive change. Second, clinical techniques and research trials, particularly those that involve physical therapies and attribute positive outcomes to the efficacy of physical strategies, should consider that the cognitive effects of treatment may be active components in promoting physical improvement. Finally, information provided to patients can have an effect on clinical assessments.

The current results should be interpreted in light of several limitations. First, this study used a convenience sample which may have limited external validity. In this sense, the current work may lay the groundwork for further more controlled investigation. Second, aside from excluding those subjects who had participated in back-school or multidisciplinary pain management programs, the nature or extent of information, including diagnoses, that had been provided to subjects prior to their participation was not assessed. It is possible that previous advice and treatment influenced the interaction between cognitive and physical change. Similarly, it is possible that expectations about ensuing treatment may have affected response to education. Importantly however, in either case an effect on treatment outcome does not corrupt the main finding of the study, that being an association between cognitive and physical change. Third, the short period between assessments may have had an effect on the post-education data via perseveration or performance bias. Although one would expect a systematic effect across the group, a possible impact cannot be excluded. Finally, we selected cognitive assessments that were previously shown to be sensitive to change with a one-to-one education intervention. It is possible that other cognitive variables, for example fear of pain and (re)injury (Watson et al., 1997), are more closely associated with physical performance and further work could address this issue.

In summary, the findings of this study suggest that change in pain attitudes and beliefs is significantly associated with change in physical performance, at least in the simple tasks used here. Further research is required to evaluate this relationship when performance is not dependent on volitional control, and to identify the mechanisms through which this effect is mediated. The results support previous assertions that the consideration of pain cognitions should be included in the assessment and management of people with CLBP.

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