How Do Pain-Response Patterns Influence the Course of Acute Low Back Pain? A Longitudinal Cohort Study

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Research Article

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Abstract

Background Pain-response patterns influence the daily activities and behavior of patients with low back pain (LBP). They are also a potential risk factor for pain persistence. Previous studies identified three subgroups of pain-response patterns: avoidance, endurance, and adaptive. In this study, we investigated the interaction effects of distinct pain-response patterns on pain intensity, disability and movement control impairment (MCI).

Methods The 66 participants in this prospective cohort study had acute LBP, assessed at four time points over 6 months. Demographic, clinical and psychosocial data were collected, and MCI was examined.

Results The results showed no significant between-group interactions of the different pain-response patterns with pain intensity, disability or MCI. However, within-group decreases in pain intensity and the disability level from the acute to the subacute phase were identified. In addition, the relative risk of persistent LBP was higher in the endurance response subgroup than in the adaptive subgroup at 6 months. MCI remained stable and at a low level throughout the observation period and did not correlate with pain or disability.

Conclusions Screening for pain-response patterns may lead to a better understanding of patients’ underlying motivation in the broader context of their valued goals. Our findings provide further evidence of altered movement control throughout the course of LBP and thus the importance of early interventions. However, MCI tests allowing more subtle assessments of movement control are needed. Finally, patients with an acute episode of LBP may benefit from a multidimensional clinical approach that takes into account both physical and psychological health.

Introduction

Acute low back pain (LBP) has a favorable prognosis, with the majority of patients recovering within 6 weeks [1]. However, some patients will develop disabling persistent or recurrent LBP [e.g. 1,2]. In the absence of an identifiable specific pathology, the nature of the underlying multidimensional pain drivers has raised both clinical and research interest [3–5]. Several studies have shown that the interactions of psychosocial and biomechanical factors are important in the development of LBP [5–8]. Although LBP remains a highly individual experience, the pain responses are of two basic types, provocative or protective [9–12], and derive from psychological aspects that include cognition (e.g., beliefs, thought suppression), affect (e.g., fear/anxiety, mood), and behavior (e.g., persistence, avoidance, pacing) [11–13]. Based on these factors, three subgroups of pain-response patterns have been defined: fear-avoidance responses (FAR), endurance responses (ER), also described as overactivity [11,14], and adaptive responses (AR) [15]. The FAR pattern consists of activity avoidance due to the conviction that certain activities will worsen the pain. However, the resulting structural/functional deconditioning and, frequently, the associated depression may promote pain persistence. In the ER pattern, overactivity and task persistence despite pain may lead to a dramatic increase of pain intensity that prohibits further activity
The long-term consequences of this strategy include pain exacerbation due to overuse or soft-tissue micro-trauma [6,12]. The AR pattern involves coping strategies aimed at achieving an optimal balance between activity and regeneration and often results in favorable outcomes [6,12].

In contrast to the AR pattern, the FAR and ER patterns pose higher risks of persistent pain and disability, as the maladaptive changes in musculoskeletal structures impede accurate movement control, albeit through opposite triggers [9,11,12]. The resulting changes in lumbo-pelvic kinematics may lead to movement control impairment (MCI) [16–18], an underlying driving mechanism that develops secondary to pain [5,16,19,20]. MCI is characterized by the inability to actively control the position of the low back during functional movements [18], either because active movement of the spine is limited by increased muscle activities that place more strain on the spine [16,21] or because of an impaired ability to actively control movement of the back in a neutral position during functional activities [18]. Although interventions aimed at improving MCI may be effective in reducing pain and disability, the factors that lead to the initial development of MCI in the course of LBP are largely unknown. Furthermore, the contribution of MCI itself to persistent pain merits further investigation [4,5,8,22–24]. In this study we explored the time-related effects and interactions of pain-response patterns on pain intensity, disability and MCI in the course of acute LBP.

**Methods**

**Study Design**

In this prospective cohort study patients were assessed at 4 time points: ≤ 4 (baseline), 8, 12, and 26 weeks after the onset of acute LBP. At each time point, clinical tests were performed. Patient-reported outcomes were collected using an online survey that queried medical history, demographic variables, LBP-associated pain and the disability level. All participants provided informed consent prior to the start of the examination. The Medical Ethics Committee of the Canton of Zurich, Switzerland (BASEC-no. 2016-02096) approved the study protocol. All experiments were performed in accordance with relevant guidelines and regulations.

**Participants**

The 66 patients with acute LBP were recruited from private physiotherapy practices, two hospital outpatient practices, and the University Campus using advertisements and mailing lists between December 2017 and October 2018. Inclusion criteria were 1) onset of acute LBP with or without radiation of pain within the last 4 weeks, 2) in case of recurrent LBP: pain-free episode at least 3 months prior to pain onset, 3) age 18–65 years and 4) sufficient German language skills to fill out the questionnaires. The exclusion criteria were: 1) signs of serious pathology, 2) major psychiatric illness necessitating psychiatric/psychological consultations, and 3) current pregnancy or recent birth (past 12 months). Of the 89 candidates screened for eligibility, 66 were enrolled at baseline. Of this group, 86% (n= 57) were available at week 8, 83% (n=55) at week 12, and 79% (n=52) at week 26. The most common reasons for loss-to-follow up were insufficient adherence to the schedule of clinical tests or questionnaire completion.
and pregnancy (see Figure 1 Supplementary Material). There were no differences between participants and dropouts at baseline.

**Patient-reported outcome measures.** The online survey was sent as a link by email and the patients were asked to complete the questionnaires within 2 days. Patients who did not complete the questionnaires within this time were sent an electronic reminder, followed by a phone call in case of no response.

**Demographic and clinical variables.** Baseline sociodemographic data on sex, age, marital status, education level, and number of previous LBP episodes were collected, as well as information on the use of medical services, and sick leave.

**Pain intensity.** Present pain, worst pain and average pain intensity of the past week were measured at all four time points using a numeric self-rating scale (NRS) ranging from 0 to 10. The mean pain intensity was then calculated. Areas of referred pain were also documented.

**LBP associated disability.** The Oswestry Disability Index (ODI) quantifies overall functional disability. The German version of the ODI has excellent test-retest reliability ($r = 0.96$) and strong correlations with the Roland Morris Disability Questionnaire ($r = 0.8$) in patients with chronic pain [25].

**Depression.** The 21-item Depression Anxiety Stress Scale (DASS) questionnaire was designed to assess the severity of depression, anxiety and stress using three subscales [26]. Depression has a cutoff of >10 sum score on the subscale depression, with high internal consistency (Cronbach's alpha 0.91) and construct validity ($r = 0.68$) with the Beck Depression Inventory [27].

**Pain-response patterns.** The Avoidance-Endurance Questionnaire (AEQ) was designed to assess pain-response patterns according to four different subgroups: adaptive response (AR), fear-avoidance responses (FAR), distress endurance responses (DER), and eustress-endurance responses (ER) based on the Avoidance-Endurance model [15]. The subgroups were established using the thought suppression scale (TSS) and the behavioral endurance scale (BES), together with the depression subscale of the DASS [28] (S1 Table).

**Clinical examination.** At each time point, clinical data on pain, MCI, and neurological status (sensory neuron and motor responses) were collected to screen for serious pathology and re-control the exclusion criteria. All investigators underwent a 2-hour training session to ensure the intra- and inter-tester reliability of the clinical tests and study procedure.

Lumbar movement control abilities were evaluated using a battery comprising six active direction-specific movement tests for flexion, extension and rotation. Investigators provided verbal movement instructions and repeated them once in case of incorrect movement execution. Investigators then rated the execution as correct (negative = 0 points) or incorrect (positive = 1 point), with total scores ranging from 0 to 6 and a high score interpreted as high impairment of movement control [29]. The discriminative validity of the test battery in patients with LBP vs. healthy controls was previously demonstrated, with mean scores of
2.2 in patients with LBP and 0.75 in controls (p<0.05) and good to excellent intra- and inter-tester reliability [18,29,30].

**Statistical analyses**

Descriptive statistics were used to screen for disproportional participant characteristics and data outliers. A 2-way repeated measures analysis of variance (ANOVA) was then conducted with pain-response patterns as the between-subjects factor, time as the within-subjects factor (baseline, 8, 12 and 26 weeks) and pain intensity, disability and MCI as outcome variables. In case of significant time effects, Bonferroni post-hoc tests were applied to determine within-subject differences. Mean values were substituted for missing values. Because age and sex were considered to impact pain, disability and MCI, adjustments were made for their effects using a repeated measure analysis of covariance (ANCOVA). A further adjustment was included for the number of previous LBP episodes (0, 1–2, 3–4, and >4). The relative risk (RR) of pain persistence in each subgroup was examined at 12 and 26 weeks based on two pain categories: < NRS 3/10 and ≥NRS 3/10. Finally, the bivariate correlations of pain intensity, disability, and MCI were calculated using Spearman's correlations. The significance level was set at p < 0.05. SPSS 25.0 (Statistical Package for the Social Sciences) was used for all statistical analyses.

**Results**

**Sample characteristics**

The 66 patients enrolled at baseline had a mean age of 39.7 (SD 12.8) years. The majority were female (53%). Education levels widely differed, with the majority holding a university degree (60.6%). The average pain intensity at baseline was 4.3 (SD 1.8). The mean reported days of work absence due to sickness was 1.8 (range 0–14). Most participants reported at least one previous episode of LBP. Depression, anxiety and stress scores were low. Based on the AEQ classification of pain-response patterns, the ER subgroup comprised 38 (57.6%) patients, the AR subgroup 24 (36.4%) patients, and the DER subgroup 1 patient. The mean MCI score at baseline indicated impairment. Table 1 shows the sample characteristics at baseline.

**Table 1. Baseline characteristics (n=66)**
| Characteristics                                      | Mean (SD) | Range or n (%) |
|------------------------------------------------------|-----------|----------------|
| Age                                                  | 39.7 (12.8)| 20-63          |
| Sex (female)                                         |           | 35 (53)        |
| Education / Graduation                               |           |                |
| Apprenticeship                                      | 18 (27.3) |                |
| High school certificate                              | 5 (7.6)   |                |
| University                                           | 40 (60.6) |                |
| Other                                                | 3 (4.5)   |                |
| Medical primary care / - treatments                  |           |                |
| Yes                                                  | 41 (62.1) |                |
| No                                                   | 21 (31.8) |                |
| Not reported                                         | 4 (6.1)   |                |
| Previous episodes (n)                                |           |                |
| None                                                 | 16 (24.2) |                |
| 1–2                                                  | 23 (34.8) |                |
| 3–4                                                  | 13 (19.7) |                |
| > 4                                                  | 10 (15.2) |                |
| Not reported                                         | 4 (6.1)   |                |
| Mean number of days sick leave                       | 1.83 (3.4)| 0-14           |
| Pain intensity (NRS)                                 | 4.3 (1.79)| 0-8            |
| Radiating pain in other regions                      |           |                |
| Yes                                                  | 28 (42.4) |                |
| No                                                   | 34 (51.5) |                |
| Not reported                                         | 4 (6.1)   |                |
| LBP associated disability (ODI)                      | 17.4 (11.5)| 0-63          |
| Movement control impairment (MCI)                    | 2.0 (1.4) | 0-6            |
| Depression Anxiety Stress Scale (DASS)               |           |                |
| Depression                                           | 2.4 (3.1) | 0-16           |
| Anxiety                                              | 1.5 (2.0) | 0-9            |
Stress 4.4 (3.4) 0-17

| Pain responses (Avoidance Endurance Questionnaire; AEQ) |  
|---------------------------------------------------------|
| Fear avoidance response (FAR) | 0 (0) |
| Distress endurance response (DER) | 1 (1.5) |
| Eustress endurance response (ER) | 38 (57.6) |
| Adaptative response (AR) | 24 (36.4) |
| Not reported | 3 (4.5) |

NRS, numeric self-rating scale; ODI, Oswestry Disability Index

Prospective analysis of outcome variables in ER and AR subgroups

Table 2 presents the means and SDs of the outcome variables and the results of the 2-way repeated-measurement ANOVAs. At the final follow-up, the participant in the DER subgroup was excluded from the analysis due to the small group size. A significant time effect for pain intensity \( F (df \ 3) = 37.661, p < 0.001 \) and disability \( F (df \ 3) = 15.352, p < 0.001 \), but not for MCI, was detected. Bonferroni post-hoc tests revealed a significant decrease in both pain intensity (effect size \( f = 0.90 \)) and disability (effect size \( f = 0.59 \)) between baseline and 8 weeks (Bonferroni \( p < 0.001 \) for both).

Table 2. Means (SDs) of the outcome variables for Endurance Response and Adaptive Response patient subgroups plus 2-way ANOVA (n = 51)
### Results of 2-way ANOVA

|                          | Mean (SD) | Mean (SD) | Mean (SD) | Mean (SD) | Results of 2-way ANOVA |
|--------------------------|-----------|-----------|-----------|-----------|------------------------|
|                          | Baseline  | 8 weeks   | 12 weeks  | 26 weeks  | Group (df = 1) F (P)   |
|                          |           |           |           |           | Time (df = 3) F (P)    |
|                          |           |           |           |           | G x T (df = 3) F (P)   |
| **Pain intensity (NRS)** |           |           |           |           |                        |
| ER                       | 4.03 (1.57) | 1.91 (1.53) | 2.21 (1.74) | 1.71 (1.53) | 2.813 (0.100)          |
|                          | 37.66 (0.000) | 1.021 (0.380) |
| AR                       | 3.65 (1.84) | 1.76 (1.56) | 1.47 (1.59) | 0.71 (1.11)          |
| **ODI**                  |           |           |           |           |                        |
| ER                       | 17.06 (10.59) | 8.56 (7.55) | 10.50 (9.73) | 8.91 (10.61) | 1.621 (0.209)          |
|                          | 15.35 (0.000) | 0.882 (0.435) |
| AR                       | 14.18 (7.73) | 8.59 (7.42) | 6.88 (7.27) | 4.76 (8.28)          |
| **MCI**                  |           |           |           |           |                        |
| ER                       | 2.03 (1.55) | 1.91 (1.37) | 2.00 (1.10) | 2.03 (1.29)          |
|                          | 0.147 (0.703) | 0.04 (0.986) | 0.209 (0.882) |
| AR                       | 2.06 (1.03) | 2.18 (1.38) | 2.18 (1.24) | 2.00 (1.12)          |

ER, eustress endurance responses; AR, adaptive responses; F = Fisher criterion; df = degrees of freedom;

P = P-value; NRS, numeric self-rating scale; ODI, Oswestry Disability Index; MCI, movement control impairment

There were no significant time × group interaction effects among the outcome variables. (see Figure 2 Supplementary Material).

Patients assigned to the ER group had a 1.4-fold (95% confidence interval [CI]: 0.6–3.2) higher risk of increased pain (≥ NRS 3/10) at 12 weeks but a 5.5-fold (95%CI: 0.8–39.1) higher risk at 26 weeks of follow-up (Table 3).

Table 3. Relative risk for Endurance Response (n=34) and Adaptive Response (n=17) patient subgroups
|                | 12 weeks   |          | 26 weeks   |          |
|----------------|------------|----------|------------|----------|
|                | NRS ≥ 3/10 | NRS < 3/10 | NRS ≥ 3/10 | NRS < 3/10 |
| Subgroup       |            |          |            |          |
| ER, n (%)      | 14 (73.7)  | 20 (62.5) | 11 (91.7)  | 23 (59.0) |
| AR, n (%)      | 5 (26.3)   | 12 (37.5) | 1 (8.3)    | 16 (41.0) |
| RR (95% confidence interval) | 1.4 (0.6–3.2) |          | 5.5 (0.83–9.1) |          |
| P-values       | 0.4318     |          | 0.0887     |          |

ER, eustress endurance responses; AR adaptive responses; NRS, numeric self-rating scale; RR, relative risk

According to the ANCOVA, there were no significant effects of age (assumption of sphericity: F = 0.268, p = 0.848), sex (Greenhouse-Geisser: F =0.320, p = 0.780) or the number of previous LBP episodes (assumption of sphericity: F = 1.474, p = 0.224) on pain intensity over time. Age (Greenhouse-Geisser: F = 0.020, p = 0.991), and sex (Greenhouse-Geisser: F = 1.652, p = 0.189) also had no effects on either disability or MCI (assumption of sphericity: F = 0.1.943, p = 0.125 for age; F = 0.762, p = 0.517 for sex).

Pain intensity correlated significantly with disability at 4 ($r_s = 0.29; p = 0.04$), 8 ($r_s = 0.61; p < 0.001$), 12 ($r_s = 0.70; p < 0.001$) and 26 ($r_s = 0.66; p < 0.001$) weeks. However, neither pain intensity nor disability was significantly related to MCI at any of the time points. The exception was disability, which correlated significantly ($r_s = 0.30; p = 0.04$) with MCI at the baseline time point of ≤ 4 weeks (S2 Table).

**Discussion**

This study investigated the time-related effects and interactions of pain-response patterns on pain intensity, disability and MCI after an episode of acute LBP, based on simultaneously collected clinical data, self-reported outcomes and trunk movement control determinations (MCI score). Pain intensity and disability decreased significantly over time, while MCI scores were consistently low. Contrary to our expectations, neither ER nor AR had an impact on the outcome variables, although the risk of persistent pain was higher in the ER than in the AR subgroup.

Most acute LBP episodes are transient [1] with modest or no aftereffects [3]. In our patients, pain intensity and disability decreased significantly within the first 8 weeks but remained stable thereafter, until the last follow-up at 26 weeks. Our results are consistent with previous descriptions of LBP trajectories, including reports on the natural course of LBP [31–34]. However, time-averaged reporting for pain and disability does not reflect individual variability [35], as the distinct trajectories of LBP may include a less pronounced pain decrease and the persistence of pain at an overall high level in patients with severe or fluctuating pain [31–34]. Despite the different pain characteristics reported by our patients, the LBP
episode assessed in our study was assumed to be non-transient, and while the pain intensity remained at a low level, it may well have influenced the quality of life of our patients. In our study, previous episodes of LBP had no influence on pain intensity and disability, but together with awkward posture and longer sitting time they may be predictive of recurrent LBP within 12 months [36].

During a LBP episode, pain responses define patterns of daily activities and behavior. As such, they are a potential risk factor for pain persistence. The pain-response patterns defined by the AR, ER and DER subgroups were constructed using AEQ subscales and a depression inventory. The presence of depressive symptoms requires classification into the DER or FAR subgroup. The only patient in our study with depression was categorized in the DER subgroup; none of the patients exhibited the FAR pain-response pattern, recognized as a significant prognostic factor of persistent LBP [37,38]. However, the reported prevalence of the FAR pattern is < 10% [12], whereas that of ER is ~40% [12,13]. The absence of the FAR pattern in our patients reflects the fact that major psychiatric illness requiring treatment was among the exclusion criteria. Rather, the rate of self-reported depression among our patients was low, as previously shown for patients in the general population with acute LBP necessitating primary care [32,39]. Indeed, when followed over one year, patients with low pain intensity and good mental health seem to experience an improvement of LBP, whereas the opposite features are associated with persistent high-level pain [33]. However, the validity of these causality relationships and their prognostic implications require further investigation [31].

The majority of our patients exhibited the ER pain-response pattern. Recent research demonstrated the harm caused by ER behavior with respect to pain intensity and the long-term consequences [7,9,11,12]. Conversely, beneficial effects related to optimal pain coping strategies, such as avoidance adapted to the situation and low persistence behavior, have been reported for the AR pattern [12,40]. Nonetheless, the outcomes differed from those expected based on the features of these two subgroups, as ER and AR patients did not significantly differ regarding pain intensity and disability, although both scores were higher in the ER subgroup. Nonetheless, a calculation of the RR for ER compared to AR patients revealed an elevated risk of pain persistence in the former at 12 weeks and especially at 26 weeks. This is consistent with the influence of ER-type pain responses on pain intensity and the negative long-term consequences thereof [7,9,11,12], as these patients may feel conflicted by the desire for pain relief but also to maintain their usual activities [7]; see personal goals [10]. In fact, the meta-analysis of Andrews et al. (2012) linked endurance responses with elevated pain and poor functioning in daily tasks [9].

The majority of our patients presented with MCI, with a mean score that remained unchanged throughout the 26-week follow-up. Similar results were reported in a study of patients with acute, subacute, and chronic LBP [29]. However, an additional analysis by those authors in a case control study revealed significant differences in MCI, with scores increasing successively from acute to chronic LBP [18]. The longer observational time in our study may have masked differences in the scores of our patients. We found that MCI does not differ in patients with AR and ER responses, and therefore that these responses do not directly contribute to movement control. However, this finding is difficult to explain, given that the overuse that characterizes ER-type responses results in maladaptive changes in musculoskeletal
structures that impede accurate movement control. We therefore hypothesize that a time-dependent persistence in pain intensity in the ER subgroup limits movement control but this behavior is not reflected in the MCI tests, especially since pain intensity was not associated with the MCI scores. In fact, evidence for the construct validity of the MCI tests is lacking. Most MCI assessments are based on interpretations of the quality of movement execution and the identification of detrimental mechanism involving the lumbar spine [30]. Indeed, prospective studies revealed a reduction in disability scores in patients treated with individual movement control exercises [(20) 36]. Whether pain reduction was achieved in those patients could not be ascertained from the data. Further studies are needed to determine whether pain reduction is achieved by motor control interventions, as in the absence of prospective studies the relationship between MCI and pain remains unclear [41–44]. The adaptive changes in trunk motor control are also poorly understood, given the variation among individuals depending on tissue integrity and task performance [7,22,39]. Despite the gradual shift from categorized movement control intervention toward a more multidimensional understanding of the complexity of LBP [45], further work in this area is mandatory to link MCI to pain provocation [45–47], as movement control may turn out to be of less relevance over the course of acute LBP.

Conclusion

In conclusion, LBP is multidimensional in terms of its mechanisms and manifestations, both of which must be recognized in its treatment. Our investigation of the psychological and physical aspects of LBP revealed a need for a comprehensive clinical approach to LBP and a continued exploration of the provocative underlying factors [47,48]. A key strength of our study was its cohort design and the simultaneous assessments of clinical data, self-reported outcomes and trunk movement control that were performed at each of the four time points. However, due to the small sample size, caution must be applied in interpreting our findings, which may not be representative. Notably, our population had a high educational level whereas people with a lower educational level or in poor general condition due to acute pain may be less compliant with the demands of study participation [49]. In addition, as our patients represented only the AR and ER pain-response patterns, studies of FAR and DER responses and their possible effects on outcome variables are still needed. Nonetheless, our findings indicate that screening pain-response patterns may provide a better understanding of patients’ underlying motivation in managing their LBP and thus an improved therapeutic strategy [12,47]. For example, AR patients at lower risk of persistent LBP may need less treatment, the benefits of which would include cost savings [12,50,51]. A recognition of these patients requires an in-depth understanding of the psychological aspects of LBP and adequate communication skills in clinical practice [52–55]. Given the altered movement control throughout the course of LBP, also identified in this study, early interventions of motor control training should be considered [45,56,57]. Furthermore, our results provide additional evidence that MCI tests do not allow for more subtle assessments of movement control. Moreover, they also highlight the importance of a therapeutic shift toward a multidimensional approach to acute episodes of LBP, one that takes into account the physical and psychological characteristics of these patients.
Abbreviations

AEQ Avoidance-Endurance Questionnaire
ANCOVA Analysis of Covariance
ANOVA Analysis of Variance
AR Adaptive Responses
BES Behavioral Endurance Scale
DASS Depression Anxiety Stress Scale
DER Distress Endurance Responses
ER Endurance Responses
FAR Fear-Avoidance Responses
LBP Low Back Pain
MCI Movement Control Impairment
NRS Numeric self-Rating Scale
ODI Oswestry Disability Index
RR Relative Risk
TSS Thought Suppression Scale

Declarations

Ethics approval and consent to participate: All participants provided informed consent prior to the start of the examination. The Medical Ethics Committee of the Canton of Zurich, Switzerland (BASEC-no. 2016-02096) approved the study protocol.

Consent for publication: Not applicable.

Availability of data and materials: Open access will be granted on Zanodo for the datasets used and/or analyzed during the current study or from the corresponding author on reasonable request.

Competing interests: The authors declare that they have no competing interests.

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**References**

1. Costa L da CM, Maher CG, Hancock MJ, McAuley JH, Herbert RD, Costa LOP. The prognosis of acute and persistent low-back pain: a meta-analysis. CMAJ. 2012 Aug 7;184(11):E613–24.

2. Grotle M, Brox JI, Veierød MB, Glomsrød B, Lønn JH, Vollestad NK. Clinical course and prognostic factors in acute low back pain: patients consulting primary care for the first time. Spine. 2005 Apr 15;30(8):976–82.

3. Hartvigsen J, Hancock MJ, Kongsted A, Louw Q, Ferreira ML, Genevay S, et al. What low back pain is and why we need to pay attention. The Lancet [Internet]. 2018 Mar [cited 2018 May 16]; Available from: http://linkinghub.elsevier.com/retrieve/pii/S014067361830480X

4. Hodges PW, Moseley GL. Pain and motor control of the lumbopelvic region: effect and possible mechanisms. Journal of Electromyography and Kinesiology. 2003 Aug;13(4):361–70.

5. O'Sullivan P. Diagnosis and classification of chronic low back pain disorders: maladaptive movement and motor control impairments as underlying mechanism. Man Ther. 2005 Nov;10(4):242–55.

6. Hasenbring M, Lundberg M, Parker R, Söderlund A, Bolton B, Smeets R, et al. Pain, Mind, and Movement in Musculoskeletal Pain. The Clinical Journal of Pain. 2015 Feb 1;31(2):95–6.

7. Hasenbring MI, Andrews NE, Ebenbichler G. Overactivity in Chronic Pain, the Role of Pain-related Endurance and Neuromuscular Activity: An Interdisciplinary, Narrative Review. Clin J Pain. 2020 Mar;36(3):162–71.

8. Karayannis NV, Jull GA, Hodges PW. Physiotherapy movement based classification approaches to low back pain: comparison of subgroups through review and developer/expert survey. BMC Musculoskeletal Disorders. 2012 Dec;13(1):24.

9. Andrews NE, Strong J, Meredith PJ. Activity Pacing, Avoidance, Endurance, and Associations With Patient Functioning in Chronic Pain: A Systematic Review and Meta-Analysis. Archives of Physical Medicine and Rehabilitation. 2012 Nov 1;93(11):2109-2121.e7.

10. Damme SV, Kindermans H. A Self-Regulation Perspective on Avoidance and Persistence Behavior in Chronic Pain. The Clinical Journal of Pain. 2015 Feb 1;31(2):115–22.

11. Esteve R, Ramírez-Maestre C, Peters ML, Serrano-Ibáñez ER, Ruíz-Párraga GT, López-Martínez AE. Development and Initial Validation of the Activity Patterns Scale in Patients With Chronic Pain. The Journal of Pain. 2016 Apr 1;17(4):451–61.

12. Hasenbring MI, Hallner D, Klasen B, Streitlein-Böhme I, Willburger R, Rusche H. Pain-related avoidance versus endurance in primary care patients with subacute back pain: psychological characteristics
and outcome at a 6-month follow-up. Pain. 2012 Jan;153(1):211–7.

13. Plaas H, Sudhaus S, Willburger R, Hasenbring MI. Physical activity and low back pain: the role of subgroups based on the avoidance-endurance model. Disabil Rehabil. 2014;36(9):749–55.

14. Andrews NE, Strong J, Meredith PJ. Overactivity in chronic pain: is it a valid construct? Pain. 2015 Oct;156(10):1991–2000.

15. Hasenbring MI, Hallner D, Rusu AC. Fear-avoidance- and endurance-related responses to pain: Development and validation of the Avoidance-Endurance Questionnaire (AEQ). European Journal of Pain. 2009 Jul 1;13(6):620–8.

16. Danckaerts W, O’Sullivan P, Burnett A, Straker L, Davey P, Gupta R. Discriminating Healthy Controls and Two Clinical Subgroups of Nonspecific Chronic Low Back Pain Patients Using Trunk Muscle Activation and Lumbosacral Kinematics of Postures and Movements: A Statistical Classification Model. Spine. 2009 Jul 1;34(15):1610–1618.

17. Hodges PW, Tucker K. Moving differently in pain: A new theory to explain the adaptation to pain. [Review]. Pain. 2011 Mar;152(3).

18. Luomajoki H, Kool J, de Bruin ED, Airaksinen O. Movement control tests of the low back; evaluation of the difference between patients with low back pain and healthy controls. BMC Musculoskelet Disord. 2008 Dec 24;9:170.

19. Brumagne S, Janssens L, Knapen S, Claeys K, Suuden-Johanson E. Persons with recurrent low back pain exhibit a rigid postural control strategy. Eur Spine J. 2008 Sep;17(9):1177–84.

20. Luomajoki H, Kool J, de Bruin ED, Airaksinen O. Improvement in low back movement control, decreased pain and disability, resulting from specific exercise intervention. Sports Med Arthrosc Rehabil Ther Technol. 2010 Apr 23;2:11.

21. Hodges PW, Coppieters MW, MacDonald D, Cholewicki J. New insight into motor adaptation to pain revealed by a combination of modelling and empirical approaches. European Journal of Pain. 2013;17(8):1138–46.

22. van Dieën JH, Reeves NP, Kawchuk G, van Dillen L, Hodges PW. Motor Control Changes in Low-Back Pain: Divergence in Presentations and Mechanisms. J Orthop Sports Phys Ther. 2018 Jun 12;1–24.

23. Fersum KV, O’Sullivan P, Skouen JS, Smith A, Kvåle A. Efficacy of classification-based cognitive functional therapy in patients with non-specific chronic low back pain: A randomized controlled trial. European Journal of Pain. 2013;17(6):916–28.

24. Karayannis NV, Smeets RJEM, Hoorn W van den, Hodges PW. Fear of Movement Is Related to Trunk Stiffness in Low Back Pain. PLOS ONE. 2013 Jun 27;8(6):e67779.

25. Mannion AF, Junge A, Fairbank JCT, Dvorak J, Grob D. Development of a German version of the Oswestry Disability Index. Part 1: cross-cultural adaptation, reliability, and validity. Eur Spine J. 2006 Feb;15(1):55–65.

26. Nilges P, Essau C. [Depression, anxiety and stress scales: DASS–A screening procedure not only for pain patients]. Schmerz. 2015 Dec;29(6):649–57.
27. Richter P, Werner J, Heerlein A, Kraus A, Sauer H. On the Validity of the Beck Depression Inventory. PSP. 1998;31(3):160–8.

28. Scholich SL, Hallner D, Wittenberg RH, Rusu AC, Hasenbring ML. Schmerzverarbeitungspattern bei chronischen Rückenschmerzen Pilotstudie. Schmerz. 2011 Mar 20;25(2):184.

29. Luomajoki H, Kool J, de Bruin ED, Airaksinen O. Reliability of movement control tests in the lumbar spine. BMC Musculoskelet Disord. 2007 Sep 12;8:90.

30. Salvioli S, Pozzi A, Testa M. Movement Control Impairment and Low Back Pain: State of the Art of Diagnostic Framing. Medicina. 2019 Sep;55(9):548.

31. Axén I, Leboeuf-Yde C. Trajectories of low back pain. Best Practice & Research Clinical Rheumatology. 2013 Oct 1;27(5):601–12.

32. Bendayan R, Ramírez-Maestre C, Ferrer E, López A, Esteve R. From acute to chronic back pain: Using linear mixed models to explore changes in pain intensity, disability, and depression. Scandinavian Journal of Pain. 2017;16(1):45–51.

33. Dunn KM, Jordan K, Croft PR. Characterizing the Course of Low Back Pain: A Latent Class Analysis. Am J Epidemiol. 2006 Apr 15;163(8):754–61.

34. Vasseljen O, Woodhouse A, Bjøngaard JH, Leivseth L. Natural course of acute neck and low back pain in the general population: the HUNT study. Pain. 2013 Aug;154(8):1237–44.

35. Kongsted A, Kent P, Hestbaek L, Vach W. Patients with low back pain had distinct clinical course patterns that were typically neither complete recovery nor constant pain. A latent class analysis of longitudinal data. Spine J. 2015 May 1;15(5):885–94.

36. da Silva T, Mills K, Brown BT, Pocovi N, de Campos T, Maher C, et al. Recurrence of low back pain is common: a prospective inception cohort study. J Physiother. 2019;65(3):159–65.

37. Crombez G, Eccleston C, Van Damme S, Vlaeyen JWS, Karoly P. Fear-Avoidance Model of Chronic Pain: The Next Generation. The Clinical Journal of Pain. 2012;28(6):475–83.

38. Leeuw M, Goossens MEJB, Linton SJ, Crombez G, Boersma K, Vlaeyen JWS. The fear-avoidance model of musculoskeletal pain: current state of scientific evidence. J Behav Med. 2007 Feb;30(1):77–94.

39. Karayannis NV, Jull GA, Nicholas MK, Hodges PW. Psychological Features and Their Relationship to Movement-Based Subgroups in People Living With Low Back Pain. Archives of Physical Medicine and Rehabilitation. 2018 Jan 1;99(1):121–8.

40. Huijnenl IPJ, Verbuntl JA, Petersl ML, Smeetsl RJEM, Kindermansl HPJ, Roelofsl J, et al. Differences in activity-related behaviour among patients with chronic low back pain. European Journal of Pain. 2011;15(7):748–55.

41. Azevedo DC, Ferreira PH, Santos H de O, Oliveira DR, de Souza JVL, Costa LOP. Movement System Impairment-Based Classification Treatment Versus General Exercises for Chronic Low Back Pain: Randomized Controlled Trial. Phys Ther. 2018 Jan 1;98(1):28–39.
42. Sahrmann S, Azevedo DC, Dillen LV. Diagnosis and treatment of movement system impairment syndromes. Braz J Phys Ther. 2017;21(6):391–9.

43. Saner J, Kool J, Bie RA de, Sieben JM, Luomajoki H. Movement control exercise versus general exercise to reduce disability in patients with low back pain and movement control impairment. A randomised controlled trial. BMC Musculoskeletal Disorders. 2011 Dec;12(1):207.

44. Saner J, Sieben JM, Kool J, Luomajoki H, Bastiaenen CHG, de Bie RA. A tailored exercise program versus general exercise for a subgroup of patients with low back pain and movement control impairment: Short-term results of a randomised controlled trial. J Bodyw Mov Ther. 2016 Jan;20(1):189–202.

45. Hodges PW, Danneels L. Changes in Structure and Function of the Back Muscles in Low Back Pain: Different Time Points, Observations, and Mechanisms. J Orthop Sports Phys Ther. 2019 Jun;49(6):464–76.

46. Hasenbring MI, Fehrmann E. Embodied Pain: There is a Need to Reflect Interactions Between Cognitions, Behavior, and Neuromuscular Activity in Chronic Pain. The Clinical Journal of Pain. 2020 Mar;36(3):178–80.

47. O’Sullivan PB, Caneiro JP, O’Keeffe M, Smith A, Dankaerts W, Fersum K, et al. Cognitive Functional Therapy: An Integrated Behavioral Approach for the Targeted Management of Disabling Low Back Pain. Phys Ther. 2018 May;98(5):408–23.

48. O’Keeffe M, O’Sullivan PB, O’Sullivan K. Education can ‘change the world’: Can clinical education change the trajectory of individuals with back pain? Br J Sports Med. 2019 Feb 8;bjsports-2018-100190.

49. Patel MX, Doku V, Tennakoon L. Challenges in recruitment of research participants. Advances in Psychiatric Treatment. 2003 May;9(3):229–38.

50. Hill JC, Whitehurst DG, Lewis M, Bryan S, Dunn KM, Foster NE, et al. Comparison of stratified primary care management for low back pain with current best practice (STarT Back): a randomised controlled trial. The Lancet. 2011 Oct 29;378(9802):1560–71.

51. Whitehurst DGT, Bryan S, Lewis M, Hill J, Hay EM. Exploring the cost–utility of stratified primary care management for low back pain compared with current best practice within risk-defined subgroups. Ann Rheum Dis. 2012 Nov;71(11):1796–802.

52. Foster NE, Anema JR, Cherkin D, Chou R, Cohen SP, Gross DP, et al. Prevention and treatment of low back pain: evidence, challenges, and promising directions. The Lancet. 2018 Jun 9;391(10137):2368–83.

53. Foster NE, Delitto A. Embedding Psychosocial Perspectives Within Clinical Management of Low Back Pain: Integration of Psychosocially Informed Management Principles Into Physical Therapist Practice—Challenges and Opportunities. Phys Ther. 2011 May 1;91(5):790–803.

54. Meyer C, Denis CM, Berquin AD. Secondary prevention of chronic musculoskeletal pain: A systematic review of clinical trials. Annals of Physical and Rehabilitation Medicine [Internet]. 2018 Mar 22 [cited
Supporting Information

S1 Figure 1. Flow diagram. Non-eligibility or drop-outs were mainly caused of schedule reasons

S2 Figure 2. Interaction of response patterns with a) pain (NRS) b) disability (ODI) and, c) movement control impairment (MCI).

S3 Table S1. Classification scheme for determination of the pattern. AEM, Avoidance-Endurance Model; DASS, Depression Anxiety Stress Scale (depression subscale); TSS, Thought Suppression Scale; BES, Behavioral Endurance Scale

Table S2. Correlations between outcome variables at the four measurement time points. $r = 0.00-0.19$ very weak, $r = 0.20-0.39$ weak, $r = 0.40-0.59$ moderate; $r = 0.60-0.79$ strong, $r = 0.80-1.00$ very strong effect; $P = P$-value; NRS, numeric self-rating scale; ODI, Oswestry Disability Index; MCI, movement control impairment

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