

# Association between pain sensitivity in the hand and outcomes after surgery in patients with lumbar disc herniation or spinal stenosis

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## Abstract

**Purpose** To investigate the association between pain sensitivity in the hand pre-surgery, and patient-reported outcomes (PROs) in function, pain and health pre- and post-surgery in patients with disc herniation or spinal stenosis. **Methods** This is a prospective cohort study with 82 patients. Associations between pressure-, cold- and heat pain threshold (PPT, CPT, HPT) in the hand pre-surgery and Oswestry, VAS pain, EQ-5D, HADS, and Self-Efficacy Scale, pre- and three months post-surgery; were investigated with linear regression.

**Results** Patients with disc herniation more sensitive to pressure pain pre-surgery showed lower function and self-efficacy, and higher anxiety and depression pre-surgery, and lower function, and self-efficacy, and higher pain post-surgery. Results for cold pain were similar. In patients with spinal stenosis few associations with PROs were found and none for HPT and PROs.

**Conclusions** Altered pain response in pressure- and cold pain in the hand, as a sign of widespread pain pre-surgery had associations with higher pain, lower function and self-efficacy post-surgery in patients with disc herniation.

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## Introduction

Low back pain (LBP) is the condition causing most disability globally [1]. Only about 10% of all LBP problems are represented by disc herniation or spinal stenosis but they represent the most common conditions in spinal surgery [2, 3]. In these groups, the outcome is questioned since 20–35% is doubtful or dissatisfied with the results at one-year follow-up [3]. Challenges are to develop screening identifying those with increased risk of a poor prognosis and to select interventions based on prognostic factors for improvement of outcomes [2, 4]. Socio-demographic, clinical, work-related and psychological risk factors may partly explain poor outcomes after spinal surgery [5]. Another reported risk factor is insufficient pain treatment pre- and post-surgery [6]. It has been suggested that screening of somatosensory function may contribute to the understanding of pain mechanisms involved [7]. Somatosensory profiles can be assessed with quantitative

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sensory testing (QST), by measuring amongst others pressure-, cold- and heat pain thresholds (PPT, CPT and HPT). Lowered pain thresholds in QST measurement is described as an indication for central hyperexcitability [8]. This alteration in sensory thresholds can either be localized or widespread including a non-affected body regions [9].

Thermal thresholds in an affected body region were normalized in patients with spinal degenerative disease, who had recovered 6 months post-surgery, while they were not normalized in patients with remaining pain post-surgery [10]. Lowered PPT in non-affected body regions was associated with higher pre-surgery and 12 months post-surgery pain severity, but not with change in pain from pre-surgery to follow-up after hip- or knee replacement [11]. A previous analysis of the present cohort of patients with degenerative lumbar spine disorders selected for surgery showed that an altered sensory profile in both affected and non-affected body regions pre-surgery were associated with higher back- and leg pain intensity and lower mental health pre-surgery (Lindbäck Y et al. submitted manuscript 2016). However, prospective studies are needed to further examine whether these dimensions can be useful as a screening tool for outcome post-surgery. The purpose was to investigate the association between pain sensitivity in the hand pre-surgery, and patient-reported outcomes (PROs) in function, pain, and health pre- and post-surgery in patients with disc herniation or spinal stenosis. Our hypothesis was that patients more sensitive to pain in the hand, a sign of widespread altered pain response, will have higher pain, lower function, and health pre- and post-surgery.

## Method

### Study design

This is a prospective cohort study. The study conforms to the STROBE statement checklist. The study was approved by the Regional Ethics committee (Dnr 2013/410-31). The patients received oral and written information about the study and they all signed an informed consent before the measurement. Forty-seven patients (57%) were even included in Prepare, a study investigating the effect of pre-surgery physiotherapy (Clintrials.gov: NCT02454400).

### Setting

The patients were consecutively recruited at the University Spine Clinic, Linköping, Sweden, between September 2013 and December 2014. The somatosensory function was investigated with QST 1–2 weeks pre-surgery by one single investigator at the Spine Clinic. The patients filled out PROs pre- and 3 months post-surgery.

### Participants

The inclusion criteria were: age 25–80 years; the presence of leg pain with or without back pain due to lumbar disc herniation or lumbar spinal stenosis, diagnosis confirmed by magnetic resonance imaging; failure of conservative intervention (without further specification) and pain level high enough to indicate surgical intervention (discectomy or decompression surgery with or without fusion).

### Variables

A standardized QST protocol was used [12]. During QST, the patients were sitting comfortably in a quiet room with an air temperature of 22 °C. Cold and heat pain threshold (CPT and HPT) were measured by a thermic stimulator (Somedic, Hörby, Sverige). A thermode containing a peltier element was used with a stimulating area of 25 × 50 mm. The baseline temperature was + 32 °C and for the thermal measures the temperature decreased or increased with 1 °C/s within a range of +10 and + 50 °C. The thermode was held on the dominant hand on the thenar eminence muscle. The instruction was to push the stop button when the cold/heat sensation was perceived as painful.

PPT was measured with a handheld electrical pressure algometer (Somedic, Hörby, Sweden). The pressure was applied at a rate of 30 kPa/s, with a 1 cm diameter probe. The maximal pressure was 700 kPa and at that point the applied pressure was released. The patient was instructed to tell when the pressure on the hand started to become painful and at that point the applied pressure would release.

The dependent variables were the patient-reported measures pre- and post-surgery: Oswestry disability index (ODI) [13], back and leg pain intensity (VAS) [14], Health-related quality of life (EQ-5D) [15], Hospital Anxiety and Depression Scale (HADS) [16], and Self-Efficacy Scale (SES) [17]. The independent variables were PPT, CPT and HPT pre-surgery.

### Statistical methods

Statistical analysis was performed using IBM SPSS statistics version 23. The level of significance was set to 0.05. Patient demographics were presented as mean and standard deviation (SD) or numbers and frequencies. For between-group comparisons the unpaired Student's *t* test, Mann–Whitney U test or the Chi-square test were used. To assess normal distribution and outliers Kolmogorov–Smirnov, Shapiro–Wilk, skewness, kurtosis, and plots for observed value and expected or deviation from normal, respectively, was used for each variable. Some variables were deviant, but judged as sufficient in visual assessment.

Linear regression was used to analyze the associations between pain thresholds (independent variables) and patient-reported measures (dependent variables). All models were adjusted for age and gender. To assure adequate sample size, each analysis had a cases-to-independent variables ratio of about ten cases for every independent variable in the model. Missing data were few, and imputation was not used for missing data.

## Results

### Descriptive data

Patients with spinal stenosis ( $n = 53$ ) were older and had more frequently a pain duration of more than 1 year than patients with disc herniation ( $n = 29$ ) (Table 1). There were no significant differences between the patient groups in gender distribution or in the pre- and post-surgery PROs (Table 1). On group level, there were no signs of anxiety or depression; on an individual level, there were eight patients

with signs of anxiety and four patients with signs of depression according to HADS.

### Lumbar disc herniation

#### *PPT pre-surgery versus patient-reported measures pre- and post-surgery*

In patients with disc herniation, a negative association existed between PPT and ODI pre-surgery ( $P = 0.006$ ) (Table 2). Such negative association also existed between PPT and the two subscales of HADS pre-surgery (anxiety and depression) ( $P = 0.043$  and  $P < 0.001$ , respectively) and positively with SES pre-surgery ( $P = 0.017$ ).

A negative association also existed between PPT pre-surgery and ODI post-surgery ( $P = 0.020$ ) (Table 2). Furthermore, PPT pre-surgery was negatively associated with pain intensity in the leg post-surgery ( $P = 0.036$ ) and positively with self-efficacy (SES) post-surgery ( $P \leq 0.001$ ).

**Table 1** Demographic characteristics and self-reported function, pain and health of patients with disc herniation ( $n = 29$ ) and spinal stenosis ( $n = 53$ ), respectively at pre- and post-surgery

	Disc herniation	Spinal stenosis	<i>p</i> value
Age, mean (SD)	48.2 (11.3)	67.8 (7.4)	<0.001*
Women, <i>n</i> (%)	15 (51.7)	27 (50.9)	0.946
Pain duration back/leg >1 years, <i>n</i> (%)	11 (40.7)	41 (77.4)	0.001*
Pre-surgery			
ODI, mean (SD)	40.2 (16.0)	38.0 (14.7)	0.550
VAS back pain last week, mean (SD)	46.5 (28.3)	49.6 (24.1)	0.608
VAS leg pain last week, mean (SD)	60.2 (21.2)	54.8 (23.9)	0.308
EQ-5D index, mean (SD)	0.41 (0.29)	0.42 (0.32)	0.842
EQ-VAS, mean (SD)	50.7 (22.0)	51.2 (22.1)	0.923
HADS anxiety, mean (SD)	5.9 (4.1)	5.6 (3.4)	0.720
HADS depression, mean (SD)	4.5 (3.5)	4.3 (3.1)	0.729
SES, mean (SD)	125.1 (43.9)	133.2 (39.7)	0.421
3 months post-surgery			
ODI, mean (SD)	24.4 (18.8)	32.2 (16.8)	0.058
VAS back pain last week, mean (SD)	31.1 (31.2)	32.6 (23.1)	0.798
VAS leg pain last week, mean (SD)	27.3 (31.5)	28.6 (27.4)	0.845
EQ-5D index, mean (SD)	0.68 (0.26)	0.61 (0.26)	0.171
EQ-VAS, mean (SD)	71.7 (20.9)	65.6 (22.7)	0.241
HADS anxiety, mean (SD)	4.8 (3.4)	4.5 (3.5)	0.749
HADS depression, mean (SD)	3.1 (3.0)	3.6 (2.8)	0.445
SES, mean (SD)	153.6 (39.5)	151.6 (34.5)	0.822

Missing data in disc herniation group;  $\leq 2$  in all variables and in spinal stenosis group;  $\leq 1$ , except in SES pre- and post-surgery and HADS anxiety post-surgery were missing data was 4–9

SD, standard deviation; ODI, Oswestry Disability Index (0–100) (higher score indicates higher disability); VAS, Visual Analog Scale (0–100) (higher score indicates higher pain intensity); EQ-5D, EuroQol (–0.594 to 1) (higher score indicates better health); HADS, Hospital Anxiety and Depression Scale (0–21) (higher score indicates more signs of symptoms); SES, Self-Efficacy Scale (0–200) (higher score indicates better self-efficacy). \*denotes significance

**Table 2** Linear regression between pain thresholds (PPT, CPT and HPT) in the hand pre-surgery (independent variables) and self-reported function, pain and health pre- and post-surgery (dependent variables) in patients with disc herniation ( $n = 29$ )

Dependent variables	PPT hand pre-surgery			CPT hand pre-surgery			HPT hand pre-surgery					
	Beta (s)	Beta (u)	95% CI	R <sup>2</sup>	Beta (s)	Beta (u)	95% CI	R <sup>2</sup>	Beta (s)	Beta (u)	95% CI	R <sup>2</sup>
<b>Pre-surgery</b>												
ODI pre-surgery	<b>-0.706</b>	<b>-0.079**</b>	<b>-0.133 to -0.026</b>	<b>0.330</b>	<b>0.481</b>	<b>1.813*</b>	<b>0.351 to 3.274</b>	<b>0.267</b>	-0.265	-1.661	-4.573 to 1.151	0.115
VAS back pain	-0.165	-0.031	-0.140 to 0.077	0.015	0.092	0.564	-2.194 to 2.322	0.008	0.127	1.136	-3.111 to 5.383	0.013
VAS leg pain	0.060	-0.037	-0.116 to 0.042	0.060	0.145	0.666	-1.358 to 2.691	0.043	-0.037	-0.249	-3.402 to 2.903	0.026
EQ-5D index	0.110	0.000	-0.001 to 0.001	0.061	0.165	0.010	-0.017 to 0.038	0.078	-0.212	-0.020	-0.062 to 0.023	0.089
VAS EQ-5D	0.455	0.070	0.007 to 0.147	0.269	-0.277	-1.290	-3.212 to 0.631	0.222	-0.286	-1.944	-4.947 to 1.085	0.217
HADS anxiety	<b>-0.461</b>	<b>-0.013*</b>	<b>-0.026 to 0.000</b>	<b>0.420</b>	0.312	0.312	-0.031 to 0.654	0.318	-0.220	-0.357	-0.982 to 0.269	0.344
HADS depression	<b>-0.817</b>	<b>-0.020***</b>	<b>-0.029 to -0.010</b>	<b>0.511</b>	0.276	0.208	-0.097 to 0.514	0.222	-0.220	-0.244	-0.726 to 0.238	0.194
SES	<b>0.693</b>	<b>0.192*</b>	<b>0.038 to 0.345</b>	<b>0.223</b>	-0.315	-2.971	-7.087 to 1.145	0.092	0.174	2.407	-4.188 to 9.001	0.031
<b>3 months post-surgery</b>												
ODI	<b>-0.572</b>	<b>-0.072*</b>	<b>-0.132 to -0.012</b>	<b>0.327</b>	<b>0.577</b>	<b>2.362**</b>	<b>0.984 to 3.740</b>	<b>0.440</b>	-0.130	-0.771	-3.356 to 1.814	0.173
VAS back pain	-0.475	-0.099	-0.211 to 0.013	0.135	<b>0.650</b>	<b>4.404***</b>	<b>1.995 to 6.814</b>	<b>0.374</b>	0.109	1.073	-3.562 to 5.708	0.028
VAS leg pain	<b>-0.558</b>	<b>-0.117*</b>	<b>-0.226 to -0.009</b>	<b>0.196</b>	<b>0.527</b>	<b>3.607**</b>	<b>0.977 to 6.236</b>	<b>0.270</b>	-0.102	-1.019	-5.663 to 3.624	0.045
EQ-5D index	0.317	0.001	0.000 to 0.001	0.174	-0.132	-0.007	-0.031 to 0.016	0.138	-0.044	-0.004	-0.040 to 0.033	0.124
VAS EQ-5D	0.494	0.069	-0.005 to 0.143	0.159	-0.362	-1.650	-3.543 to 0.243	0.145	-0.036	-0.236	-3.340 to 2.867	0.036
HADS anxiety	-0.425	-0.010	-0.022 to 0.002	0.291	0.153	0.111	-0.196 to 0.417	0.219	0.005	0.005	-0.463 to 0.472	0.200
HADS depression	-0.421	-0.009	-0.021 to 0.004	0.100	0.173	0.113	-0.184 to 0.406	0.047	0.129	0.123	-0.333 to 0.579	0.034
SES	<b>0.921</b>	<b>0.244***</b>	<b>0.128 to 0.361</b>	<b>0.468</b>	<b>-0.738</b>	<b>-7.091***</b>	<b>-10.243 to 3.940</b>	<b>0.502</b>	0.178	2.722	-4.399 to 9.843	0.058

All models were adjusted for age and gender

Beta (s) = Standardized coefficient Beta, Beta (u) = Unstandardized coefficient Beta

PPT, pressure pain threshold; CPT, cold pain threshold; HPT, heat pain threshold; CI, confidence interval; ODI, Oswestry Disability Index (0–100) (higher score indicates higher disability);

VAS, Visual Analog Scale (0–100) (higher score indicates higher pain intensity); EQ-5D, EuroQol (-0.594 to 1) (higher score indicates better health); HADS, Hospital Anxiety and Depression Scale (0–21) (higher score indicates more signs of symptoms); SES, Self-Efficacy Scale (0–200) (higher score indicates better self-efficacy)

Bold level of significance was <0.05, \*  $P \leq 0.05$ ; \*\*  $P \leq 0.01$ ; \*\*\*  $P \leq 0.001$

*CPT pre-surgery versus patient-reported measures pre- and post-surgery*

In patients with disc herniation there was a positive association between CPT pre-surgery and ODI pre-surgery ( $P = 0.017$ ) (Table 2). Furthermore, there were also positive correlations between CPT pre-surgery and ODI post-surgery ( $P = 0.002$ ) and higher back pain and leg pain in VAS post-surgery ( $P = 0.001$  and  $P = 0.009$ , respectively). Furthermore, a negative association between CPT pre-surgery and self-efficacy (SES) post-surgery ( $P < 0.001$ ) also existed.

*HPT pre-surgery versus patient-reported measures pre- and post-surgery*

There were no associations between HPT pre-surgery and patient-reported measures pre- and post-surgery (Table 2).

**Lumbar spinal stenosis***PPT pre-surgery versus patient-reported measures pre- and post-surgery*

In patients with spinal stenosis, there were no significant associations between PPT and the pre-surgery patient-reported measures (Table 3). A negative association existed between PPT pre-surgery and HADS (anxiety) post-surgery ( $P = 0.001$ ).

*CPT pre-surgery versus patient-reported measures pre- and post-surgery*

There were positive correlations between CPT pre-surgery, and HADS (anxiety) ( $P = 0.014$ ) pre- and also post-surgery ( $P = 0.025$ ) (Table 3).

*HPT pre-surgery versus patient-reported measure pre- and post-surgery*

There were no associations between HPT pre-surgery and patient-reported measures pre- nor post-surgery (Table 3).

**Discussion**

The results showed that patients with disc herniation in lumbar spine who were more sensitive to pressure pain in the hand pre-surgery had lower function, more signs of anxiety and depression, and lower self-efficacy pre-surgery. Prospectively, more sensitivity to pressure pain pre-surgery was associated with lower function, higher pain intensity and lower self-efficacy post-surgery. The pattern

of associations was very similar for cold pain in this group of patients. Hence, our hypothesis that patients with sign of widespread altered pain response would have worse PROs pre- and post-surgery was mainly confirmed in patients with disc herniation. However, it was not confirmed in patients with spinal stenosis, since the only associations found were that patients who were more sensitive to cold pain had more signs of anxiety pre- and post-surgery, and those more sensitive to pressure pain had more signs of anxiety post-surgery. Another interesting result was that there were no associations between HPT and patient-reported measures in either of the diagnostic groups.

In a review of cross-sectional studies of patients with heterogeneous diagnoses of spinal pain, it was concluded that pain threshold had little or no correlation with disability and pain intensity [18]. In comparison, our study included homogenous groups of patients with specific diagnosis who also went through a decision making process for surgery. Our study is the first to report prospective results showing associations between high sensitivity to pressure and cold in a non-affected body region pre-surgery and lower function, higher pain intensity and lower self-efficacy post-surgery in patients with LBP. However, the results were only found in the disc herniation group. A possible reason for the different results for patients with disc herniation may be the presence of inflammation, which often causes more on-going nociceptive stimuli and constant pain experience that could cause more risk of plasticity changes in the nervous system [6]. In disc herniation, the sciatic pain is described to have both a neuropathic component with the mechanical-stimuli causing the nerve root compression and also an inflammatory component [19].

In the patients with disc herniation, PPT on the hand, as a screening tool for signs of widespread altered pain response in pain threshold, had associations with the PROs. PPT is supposed to measure deep pain and muscle sensitivity [20] and pressure pain hyperalgesia is sign of peripheral sensitization of C-fibers in tissue injury [20]. It has not yet been fully demonstrated that PPT captures central pain processing. Although in single studies hyperalgesia to pressure pain in a non-affected body region has been reported in non-specific LBP [21] and after hip- and knee replacement concluding that it might indicate central pain processing [11, 21].

PPT and CPT both measure A-delta and C-afferents, but with mechanical, respectively, thermal stimuli [7]. In this study, CPT had no associations with psychological factors pre-surgery, while lowered PPT was associated with more anxiety- and depression signs and lower self-efficacy. Further, more sensitivity to cold pain had an association with higher back pain intensity post-surgery; where PPT also had association to pain intensity but to leg pain.

**Table 3** Linear regression between pain thresholds (PPT, CPT and HPT) in the hand pre-surgery (independent variables) and self-reported function, pain and health pre- and post-surgery (dependent variables) in patients with spinal stenosis ( $n = 53$ )

Dependent variables	PPT hand pre-surgery				CPT hand pre-surgery				HPT hand pre-surgery			
	Beta (s)	Beta (u)	95% CI	$R^2$	Beta (s)	Beta (u)	95% CI	$R^2$	Beta (s)	Beta (u)	95% CI	$R^2$
Pre-surgery												
ODI	0.297	0.028	-0.009 to 0.065	0.077	0.127	0.553	-0.667 to 1.782	0.048	0.139	0.695	-0.760 to 2.150	0.050
VAS back pain	-0.111	0.017	-0.044 to 0.79	0.034	0.142	1.014	-1.003 to 3.030	0.048	0.070	0.571	-1.836 to 2.978	0.032
VAS leg pain	-0.157	-0.024	-0.084 to 0.036	0.057	0.185	1.309	-0.657 to 3.276	0.078	-0.034	-0.278	-2.648 to 2.092	0.045
EQ-5D index	-0.068	0.000	-0.001 to 0.001	0.027	-0.153	-0.014	-0.041 to 0.012	0.048	-0.051	-0.006	-0.039 to 0.027	0.027
VAS EQ-5D	-0.270	-0.038	-0.094 to 0.017	0.068	0.005	0.031	-1.832 to 1.895	0.031	-0.105	-0.790	-2.985 to 1.405	0.042
HADS anxiety	-0.070	-0.002	-0.010 to 0.007	0.043	<b>0.338</b>	<b>0.347*</b>	<b>0.072 to 0.623</b>	<b>0.154</b>	-0.090	-0.103	-0.439 to 0.233	0.048
HADS depression	0.058	0.001	-0.007 to 0.009	0.022	0.008	0.007	-0.266 to 0.281	0.020	0.180	0.190	-0.119 to 0.500	0.050
SES	-0.167	-0.043	-0.161 to 0.075	0.038	-0.083	-1.016	-4.907 to 2.875	0.031	-0.096	-1.353	-5.967 to 3.261	0.033
3 months post-surgery												
ODI	-0.179	-0.019	-0.062 to 0.023	0.059	0.031	0.155	-1.258 to 1.567	0.042	0.127	0.721	-0.933 to 2.375	0.057
VAS back pain	0.199	0.030	-0.029 to 0.088	0.050	-0.032	-0.221	-2.171 to 1.728	0.031	0.149	1.172	-1.114 to 3.458	0.050
VAS leg pain	-0.086	-0.015	-0.086 to 0.055	0.020	0.118	0.960	-1.352 to 3.271	0.030	0.071	0.661	-2.090 to 3.412	0.021
EQ-5D index	0.323	0.001	0.000 to 0.001	0.118	-0.212	-0.016	-0.038 to 0.005	0.110	0.236	0.021	-0.004 to 0.046	0.117
VAS EQ-5D	0.191	0.028	-0.031 to 0.086	0.032	0.006	0.042	-1.902 to 1.985	0.013	-0.153	-1.175	3.443 to 1.092	0.035
HADS anxiety	<b>-0.673</b>	<b>-0.015***</b>	<b>-0.024 to -0.006</b>	<b>0.216</b>	<b>0.327</b>	<b>0.330*</b>	<b>0.043 to 0.617</b>	<b>0.114</b>	-0.245	-0.284	-0.640 to 0.072	0.063
HADS depression	-0.072	-0.001	-0.009 to 0.007	0.007	0.024	0.020	-0.226 to 0.265	0.005	0.061	0.059	-0.234 to 0.351	0.008
SES	-0.039	-0.009	-0.090 to 0.073	0.244	-0.006	-0.056	-2.798 to 2.687	0.243	-0.071	-0.803	-0.960 to 2.354	0.247

All models were adjusted for age and gender

Beta (s) = Standardized coefficient Beta, Beta (u) = Unstandardized coefficient Beta

PPT, pressure pain threshold; CPT, cold pain threshold; HPT, heat pain threshold; CI, confidence interval; ODI, Oswestry Disability Index (0–100) (higher score indicates higher disability); VAS, Visual Analog Scale (0–100) (higher score indicates higher pain intensity); EQ-5D, EuroQol (- 0.594 - 1) (higher score indicates better health); HADS, Hospital Anxiety and Depression Scale (0–21) (higher score indicates more signs of symptoms); SES, Self-Efficacy Scale (0–200) (higher score indicates better self-efficacy)

Bold = level of significance was  $<0.05$ , \*  $P \leq 0.05$ ; \*\*  $P \leq 0.01$ ; \*\*\*  $P \leq 0.001$

Despite these smaller differences in PPT and CPT associations pre-surgery, this study showed that PPT and CPT mainly had similar associations with the post-surgery outcomes. PPT is the QST measure described as most sensitive for pain excitability in patients with osteoarthritis [22] as well as in chronic LBP [23]. While CPT in patients with whiplash-associated disorders (WAD) had moderate

evidence to be a predictor for outcomes in pain and disability [24]. Our result support to further analyze PPT and CPT also in degenerative lumbar spine disorders scheduled for surgery, when more sensitivity for pressure- and cold pain in a non-affected body region pre-surgery were associated with lower function, higher pain intensity and lower self-efficacy post-surgery.

The current study has its strengths and weaknesses. QST results can be influenced by psychological factors [12]. Our material was too small to adjust the regressions for possible confounding factors, e.g., psychological factors. Further, temporal summation or other dynamic QST could have been of interest, since these have been recommended to assess pain experience [7]. The difference in age between patients with disc herniation and spinal stenosis does probably not explain the differences in results since a strength of our study is that regression model was adjusted for age. Moreover, pain thresholds do not change with age [25]. Another strength of our study is that the regressions were adjusted for gender to handle the well-known sex differences in pain thresholds [20].

The results from this study should be interpreted with some caution since the study samples were relatively small. Despite this, we have compared the profile on patient-reported characteristics for the groups with the Swedish national spine register [3] and they have similar characteristics suggesting that results can be generalized to the larger Swedish population and potentially international populations with a similar health system context. Further larger prospective studies are needed to confirm our findings and be able to perform multivariate analyses. Prospective studies with validated outcomes were recently requested in a QST review concerning LBP [8]. With the associations found in this study, measuring PPT hand, a non-affected body region pre-surgery, might be a screening tool potentially capable of identifying patients with sub-optimal functional outcome, e.g., ODI.

Barriers to use QST in clinical practice are that the measurements take long time and advanced equipment is required. Development of less time consuming QST protocols are needed [7]. The handheld electrical pressure algometer used for PPT measurement is more or less standard equipment and more feasible in Spine Clinics. To investigate only a non-affected body region for screening of widespread altered pain response can help to overcome barriers for clinical use and collection of larger patients' groups is needed to further analyze the value of PPT.

## Conclusion

Measuring pressure pain threshold in a non-affected body region, as a sign for widespread altered pain response, showed that patients with lumbar disc herniation who were more sensitive to pressure pain in the hand pre-surgery had lower function, more signs of anxiety and depression and lower self-efficacy pre-surgery. Prospectively, more sensitivity to pressure pain pre-surgery was associated with lower function, higher pain intensity and lower self-

efficacy post-surgery. The results for cold pain were similar except there were no associations with psychological variables pre-surgery. In patients with spinal stenosis, there was lack of associations. Based on the associations post-surgery, further analyses of PPT in the hand as a sign of widespread altered pain response pre-surgery in patients with disc herniation are suggested.

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## Compliance with ethical standards

**Conflict of interest** None.

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