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# Structural Sensorimotor Adaptations in Young Adults with Low Back Pain

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## Abstract

Chronic low back pain (CLBP) is the largest cause of disability worldwide. There is evidence for regional structural brain adaptation in CLBP. Most studies have investigated middle-aged adults and show decreased grey matter density in pain processing regions. It is not clear if these adaptations are evident early in the lifespan of individuals with CLBP. The purpose of the study was to compare sensorimotor gray matter density in young adults with a history of CLBP with back-healthy controls. 53 young adults with a greater than 1-year history of CLBP and 29 young adults with no history of LBP participated. Clinical characteristics of the LBP group were quantified with measures of pain duration and intensity as well as pain-related fear and disability. Gray matter density was quantified with voxel-based morphometry. Whole brain and sensorimotor region of interest (ROI) comparisons between groups were made after covarying for age, sex, and total intracranial volume. ROIs were determined a priori. Associations between clinical characteristics and average gray matter density in sensorimotor ROI comparisons were explored with Pearson's correlation coefficients. Individuals with CLBP reported an average duration of pain of 4.9 (+/- 2.2 years) and average pain intensity of 5.0/10. The LBP group had greater gray matter in the right primary somatosensory cortex, right inferior parietal lobule, and right midcingulate cortex (all $p < 0.05$ FWE corrected). There were significant positive associations between average gray matter and clinical characteristics in the anterior, mid, and posterior cingulate cortices, the supramarginal gyrus, superior parietal lobule and supplementary motor area (all $p < 0.05$). We demonstrate that in young adults, CLBP is associated with structural neuroplasticity in regions involved in sensory processing, motor control, and the sensory and emotional aspects of pain experience. Increased grey matter density early in the lifespan of individuals with CLBP may reflect an adaptation to ongoing nociceptive input.



## Disciplines

Physical Therapy



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## Background

- Chronic low back pain (CLBP) is the largest cause of disability worldwide.
- There is increasing evidence for region specific patterns of structural brain adaptation in individuals with CLBP.[1]
- Most studies investigating middle aged adults show decreased gray matter density in regions associated with pain processing.[2]
- It is unclear if structural adaptations are evident early in lifespan of individuals with CLBP.
- Also unclear if adaptations occur in regions associated with motor function.

## Objective

- Compare sensorimotor gray matter density in young adults with a history of CLBP compared with back-healthy controls.

## Conclusions

- In young adults, persistent pain is linked with structural neuroplasticity in regions associated with sensory processing and motor control.
- Increased gray matter density early in the lifespan of individuals with CLBP may reflect an adaptation to ongoing nociceptive input.
- Increased average density associates with clinical characteristics.

## References

1. Kregel et al. *Structural and functional brain abnormalities in chronic low back pain: a systematic review.* Seminars in Arthritis and Rheumatism, 2015, 45: 229–237.
2. Medrano-Escalada et al. *Structural, functional and neurochemical cortical brain changes associated with chronic low back pain.* Tomography, 2022, 8: 2153-2163.
3. Smith et al. *Identifying the neural correlates of anticipatory postural control: a novel fMRI paradigm.* Human Brain Mapping, 2023, 44: 4088-4100.
Gaser et al. *CAT – a computational anatomy toolbox for the analysis of structural MRI data.* https://www.biorxiv.org/content/10.1101/2022.06.11.495736.

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## Methods

### *Subjects*

- 53 adults with chronic LBP and 29 back-healthy controls
- Low back pain defined as a history of functionally limiting low back pain symptoms for a minimum of 1 year

### *Subjective Measures*

- All participants: anxiety, depression, typical physical activity
- Participants with CLBP: pain duration, intensity, and impact, pain-related fear (Fear Avoidance Beliefs Questionnaire, FABQ), disability

**Table 1.** Group demographics

| | Healthy Controls (n = 29) | CLBP (n = 53) | p value |
|---|---|---|---|
| Age | 23.7 (4.0) | 21.9 (3.1) | 0.030 |
| Sex | | | |
| Male | 11 | 19 | |
| Female | 18 | 33 | |
| Depression | 2.9 (2.7) | 3.9 (3.3) | 0.154 |
| Anxiety | 6.9 (2.9) | 8.5 (4.3) | 0.041 |
| Physical Activity | 47.4 (13.5) | 49.9 (13.8) | 0.436 |
| Positive Affect | 23.6 (7.1) | 20.3 (7.2) | 0.103 |
| Negative Affect | 5.3 (6.0) | 8.7 (7.0) | 0.072 |
| Pain Duration | N/A | 4.9 (2.2) | |
| Pain Intensity | N/A | 50.2 (20.2) | |
| Pain Impact | N/A | 9.4 (3.9) | |
| FABQ | N/A | 10.2 (4.9) | |

### *Imaging acquisition and processing*

- T1 weighted images collected using Siemens 3T Prisma Scanner
- VBM processing completed using the CAT12 toolbox (version CAT12.7-RC2) in SPM12, running in MATLAB 2018b

### *Statistical Analysis*

- Covariates of total intracranial volume, sex, and age
- Sensorimotor regions of interest (ROIs) identified *a priori* based on previous work[3]
- Group comparisons: 2 sample T-test, FWE corrected p < 0.05 with a voxel limit of 5
- Relationships between clinical characteristics and gray matter in sensorimotor ROIs investigated with Pearson correlations
- Additional exploratory analyses of pain related limbic/sensory/cognitive ROIs

## Results

- Significant group differences in gray matter in sensorimotor ROIs are shown in Table 2 and Figure 1
- Significant linear relationships between clinical characteristics and gray matter are shown in Figure 2

**Table 2.** Group differences in gray matter in sensorimotor regions of interest

| Location | BA | Cluster size | Z | $P_{FWE\text{-}corrected}$ | MNI coordinates x | y | z |
|---|---|---|---|---|---|---|---|
| **Contrast: LBP > Control** | | | | | | | |
| R Post-Central Gyrus | 3B | 65 | 4.16 | 0.008 | 17 | -35 | 60 |
| R Inferior Parietal Lobule | 39 | 16 | 3.50 | 0.029 | 45 | -51 | 45 |
| R Pre-Central Gyrus | 4 | 6 | 3.86 | 0.038 | 20 | -33 | 60 |
| R Median Cingulate | 31 | 41 | 4.13 | 0.011 | 17 | -39 | 45 |
| L Inferior Parietal Lobule | 7 | 26 | 3.47 | 0.055 | -30 | -42 | 44 |
| **Contrast: Control > LBP** | | | | | | | |
| No suprathreshold voxels | | | | | | | |

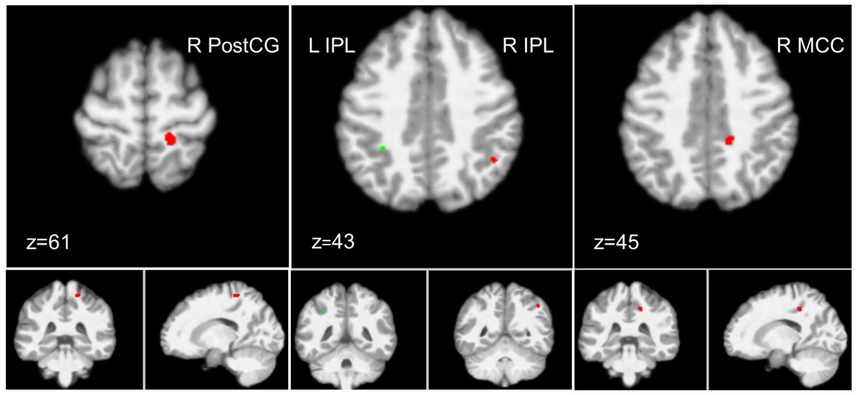


**Figure 1.** Significant group differences in gray matter in sensorimotor ROIs. Threshold p < 0.05 FWE corrected. ROIs identified using the aal atlas. PostCG – post-central gyrus. IPL – inferior parietal lobule. MCC – median cingulate cortex.

**Figure 2.** Bivariate associations between clinical characteristics and average gray matter in sensorimotor regions of interest. Partial correlations are shown after adjusting for relevant covariates: a) pain intensity and left midcingulate cortex; b) pain intensity and left posterior cingulate cortex; c) pain duration and right supramarginal gyrus; d) pain duration and right superior parietal lobule; e) pain related fear (FABQ-PA) and right supplementary motor area; f) pain-related disability (ODI) and left posterior cingulate cortex