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Multi-modal biomarkers and Computer-aided diagnosis of low back pain: A machine learning approach

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Background

- Chronic Low Back Pain (CLBP) is a widespread health issue and a major cause of disability.
- Accurate Detection is crucial for effective treatment and management.
- Traditional diagnostics have limitations as
  - it relies on subjective assessments,
  - prone to inter-observer variability,
  - lacks quantifiable metrics,
  - leading to imprecise treatments, unnecessary surgery, and reduced patient outcomes.
- Recently, image processing techniques have become valuable tools for analysing medical images and providing objective diagnostics.
- Brain neuroimaging shows potential for finding biomarkers to improve chronic LBP treatment.
- CLBP is Complex as minimal abnormalities are seen in spinal imaging, has complex pathophysiology, and poses challenges in prognosis and management.

Diagnostic Brain Biomarkers

- A recent study reviewing Electroencephalogram (EEG) patterns in chronic pain, particularly CLBP, found increased theta and alpha power compared to controls, though results were diverse.
- More recent EEG and Magnetoencephalography (MEG) studies used machine learning approaches to discriminate between chronic pain patients and healthy controls.
- Several studies reported the identification of highly distributive predictive brain patterns involving all four lobes of the brain and the cerebellum.
- According to the thalamocortical dysrhythmia theory of chronic pain, patients with CLBP tend to remain in a hyperconnected state between sub-cortical regions (including the thalamus) and somatosensory networks. The longer they stay in this state, the more severe their pain.

Potential brain biomarkers for LBP

- Cortical thickness (CT) reflects the functional organization of the human cortex and is a potential marker for the development of LBP.
- Regional changes in grey matter have been reported in pain studies (Bagarinao et al., 2014; Bernabeu-Sanz et al., 2020; Lamichhane et al., 2021).
- Morphological changes in cerebral cortical thickness (CT) and resting-state functional connectivity (rsFC) are potential biomarkers.
- Studies found that LBP patients show variations in CT and structural MRI compared to healthy controls, when correlated with self-reported clinical summary scores, physical component summary scores, and mental component summary scores.
- LBP patients often show structural and functional brain differences, with disruptions in connectivity between brain regions involved in the processing and perception of pain.
- These patients show CT aberrations in pain-related regions, predicting clinical pain scores. CT variations could also serve as imaging biomarkers for machine-learning classification of LBP vs. healthy controls.

Implication on Healthcare Systems

- Healthcare costs for LBP in the U.S. have reached nearly 1 trillion dollars (Dieleman et al., 2016), with annual treatment expenses of 100-200 billion dollars, making it one of the nation's costliest diseases.
- Diagnosing and treating chronic LBP is complicated by diverse causes and neuroimaging that fails to measure central pain mechanisms (Dieleman et al., 2016).
- Machine learning has improved predictive value in medical imaging and postoperative outcomes, and shows great potential for diagnosing chronic low back pain.

Relevance for Patient Care

- 60–80% of people experience LBP at least once in their lifetime. Globally, it is a leading cause of disability, reducing productivity and increasing healthcare costs.
- While most acute LBP patients recover within weeks or months, about one-quarter develop chronic LBP (lasting over 3 months).
- Better knowledge of the risk factors for chronic LBP can help in identifying people who are at high risk and may help implement suitable and timely preventive or treatment measures.

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