Lumbar Intervertebral Disc Compressive Strain is Greater in Participants with Medium-Impact Acute Low Back Pain Compared to Asymptomatic Controls

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INTRODUCTION: Non-specific low back pain (LBP) is a highly prevalent condition. In particular, acute LBP (LBP lasting ≤4 weeks) occurs in up to 25% of individuals each year[1]. Between 32-63% of acute LBP cases will transition to chronic LBP (pain most or every day for ≥3 months), but it remains unclear why some individuals transition to chronic LBP while others do not[1]. Characteristics of acute LBP can vary greatly, so recent studies have examined methods to categorize acute LBP severity, including an impact-based method, which combines how often LBP occurs and how often it impacts daily activities[1]. Individuals with higher impact acute LBP were found to be more likely to transition to chronic LBP[1]. Furthermore, degeneration of the intervertebral disc (IVD) is believed to be a leading cause of LBP and has been correlated with altered IVD mechanics[2,3]. However, there is a lack of in vivo studies on IVD mechanics in participants with acute LBP. Thus, the aim of this study was to examine the lumbar IVD mechanics (compressive strain following loading) in participants with low- and medium-impact acute LBP and in asymptomatic controls.

METHODS: 28 asymptomatic participants (14 males, 14 females, age: 26 [19-37] (mean [range]), BMI: 25.0 [19.3-37.1] kg/m^2) and 18 participants with non-specific acute LBP (8 males, 10 females, age: 26 [20-35], BMI: 23.9 [17.4-33.2] kg/m^2) were recruited for this IRB approved study. The acute LBP cohort was further divided into three pain categories (low-, medium-, and high-impact) based on the participants' responses to the to the following questions: (1) "Since the onset of your pain, how often have you had pain? Would you say Never, Some Days, Most Days, or Every Day?" and (2) "Since the onset of your low back pain, how often has pain limited your life or work activities? Would you say Never, Some Days, Most Days, or Every Day?" Participants who answered "Never" or "Some Days" to both questions were categorized as low-impact LBP, "Most Days" or "Every Day" were categorized as high-impact LBP, and mixed responses were categorized as medium-impact LBP[1]. Since only 2 participants fell into the high-impact group, it was excluded from the present analysis. Each participant underwent our previously established magnetic resonance (MR) imaging and exercise protocol described in **Figure 1**[4]. All MR imaging was performed on a 3.0T scanner (Prisma, Siemens Medical Solutions) using a 32-channel spine matrix coil and a sagittal T2-weighted SPACE sequence (TE/TR: 223/2500 ms: resolution 0.875x0.875x0.875 mm; matrix 320x320x80 pixels3). Manual segmentations of the L1-L2 – L5-S1 IVDs (Rhinoceros 3D, Robert McNeel and Associates) were completed, reviewed by a musculoskeletal radiologist, and used to calculate IVD height using previously published methods (**Figure 2**)[4]. IVD strain was then calculated as the percent change in IVD height from pre- to post-exercise, normalized to the pre-exercise height. Mean IVD strain was calculated for the nucleus pulposus (NP), annulus fibrosus (AF), and entire IVD[4]. Multinomial mixed-effects models were performed with IVD strain as the dependent variable, participant as a random effect, and pain category (asymptomatic, low-impact LBP, and medium-impact LBP), age, and BMI as fixed effects.

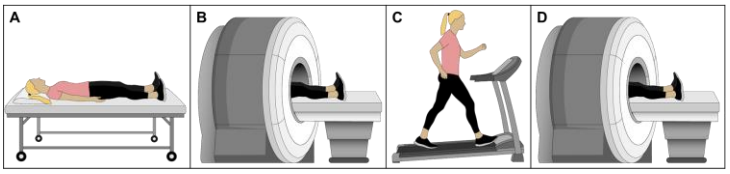

Figure 1. A. *45-minute supine rest.* ***B.*** *Pre-exercise MR imaging.* ***C.*** *30-minute treadmill walk at a speed normalized to limb length.* ***D.*** *Post-exercise MR imaging.*

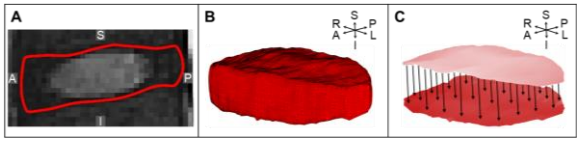

Figure 2. A*. Segmentations for each MR image slice were combined and converted into* ***B.*** *3D models of the IVD.* ***C.*** *Mean IVD height was calculated as the average distance between uniformly sampled points on the inferior (I) and superior (S) surfaces. A=anterior, P=posterior, L=left, R=right*

RESULTS: Ten participants (4 males, 6 females, age: 27 [23-30], BMI: 24.5 [18.0-33.2] kg/m^2) fell into the low-impact LBP category and six (4 males, 2 females, age: 24 [20-35], BMI: 22.7 [17.4-27.6] kg/m^2) fell into the medium-impact LBP category. No significant differences in IVD strain were detected between the asymptomatic and low-impact LBP groups for the NP (p=0.8), AF (p=0.8), or entire IVD (p=0.8) or between the low- and medium-impact LBP groups (NP: p=0.09, AF: p=0.1, entire IVD: p=0.08). However, IVD compressive strain was significantly greater in the medium-impact LBP group compared to the asymptomatic group in the NP (p=0.03), AF (p=0.04), and entire IVD (p=0.03). Mean (± standard deviation) compressive strain values for the entire IVD were 2.9 ± 1.9%, 2.9 ± 1.7%, and 4.2 ± 1.5% for the asymptomatic controls, low-impact LBP group, and medium-impact LBP group, respectively (**Figure 3**).

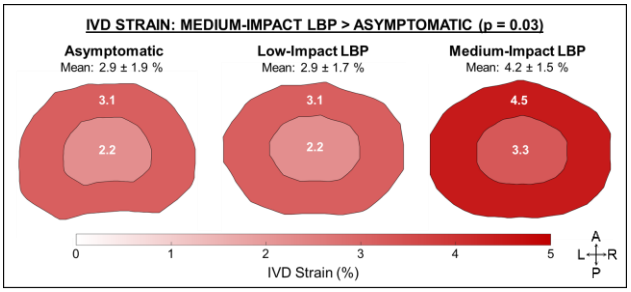

Figure 3. *Mean values (± standard deviation) of IVD strain for the entire IVD are displayed at the top of the IVD representing each pain category, and mean values for the NP and AF are written in their respective regions. More positive values of IVD strain indicate greater compressive strain.*

DISCUSSION: This study examined lumbar IVD strain following a 30-minute treadmill walk in asymptomatic participants and participants with non-specific acute LBP, categorized by pain impact[1]. Mean compressive strain values were significantly greater in the medium-impact LBP group compared to asymptomatic controls, while the low-impact LBP group was not significantly different from either. Previous cadaveric studies have found that compressive axial strain is greater in degenerated IVDs[2,3], so the increased IVD strain in the medium-impact LBP group may suggest that IVD degenerative changes are present in these individuals. Furthermore, other prior work found that individuals with higher impact acute LBP are more likely to transition to chronic LBP compared to those with low-impact acute LBP[1]. Thus, measurements of in vivo IVD mechanical function may help to identify both the potential source of LBP and those at high risk for transitioning to chronic LBP. Future studies will include more acute LBP participants to analyze the high-impact LBP group and will also investigate IVD strain in participants with chronic LBP.

SIGNIFICANCE/CLINICAL RELEVANCE: Since single time-point MR imaging is often ineffective at determining the source of LBP[5], IVD strain measurements from our MR imaging and exercise protocol may help determine if IVD degeneration is a specific reason for acute LBP. This may enable the identification of those more at risk of transitioning to chronic LBP and better guide early treatment interventions to help prevent the transition to chronic LBP.

REFERENCES: [1] Burke (2024); [2] O'Connell (2010); [3] Tavana (2021); [4] Coppock (2021); [5] Wnuk (2018)

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