Introduction. Numerous studies have been conducted to investigate the kinematics of the lumbar spine, and while many have documented its intricacies, few have analyzed the complex coupled out-of-plane rotations inherent in the low back. Some studies have suggested a possible relationship between patients having low back pain (LBP) or degenerative conditions in the lumbar region and various degrees of limited, excessive, or poorly-managed lumbar motion. Conversely, others in the orthopedic community maintain there has been no distinct correlation found between spinal mobility and clinical symptoms. Therefore, the objective of this study was to evaluate both the in-plane and coupled out-of-plane rotational magnitudes about all three motion axes in both symptomatic and asymptomatic patients.

Methods. Thirty subjects (10 healthy, 10 LBP, and 10 degenerative) volunteered to participate in this study. Institutional Review Board approval was obtained as well as informed consent for all patients (IRB #7393). Subjects in the healthy group were asymptomatic and without radiological evidence of any abnormal spinal pathologies. These subjects had never been treated for low back pain and exhibited no limitation in daily activities. Subjects classified in the low back pain group were without radiological evidence of degeneration or defects in the lumbar spine but were symptomatic and had experienced at least one episode of low back pain within a year of being evaluated for this study. In the degenerative group, subjects experienced pain prior to evaluation and were clinically classified as having a degenerative spine based on radiological evidence of one or more of the following conditions: Schmorl’s Nodes, disc bulging both with and without canal or foraminal stenosis, disc osteophyte complexes, decreased height and fluid signal in the intervertebral disc, or facet hypertrophy. In addition, the degree of degeneration was not considered severe enough to require surgery. Six of 10 subjects were diagnosed with degenerative changes at a single level, and four were identified as having degeneration at multiple levels.

Following classification into one of the three patient categories, subjects were CT scanned and evaluated under fluoroscopic surveillance. Subjects were classified into one of the three patient categories before performing the prescribed flexion/extension activity. By tracking the rotational path of the cephalad vertebrae as it articulated upon the more caudal vertebrae and summing the absolute rotation between each increment about each axis, the POR was calculated over the entire flexion/extension activity.

Results. Using both the MARM and POR methods, the average overall in-plane rotations between L1 and L5 were not significantly different between groups. Alternatively, the total out-of-plane motions over the length of all lumbar segments in the symptomatic groups were significantly greater compared to asymptomatic subjects (Table 1). The degenerative group did exhibit less overall in-plane range-of-motion compared to the healthy and LBP patients. In addition, at the L4-L5 level, patients in the healthy and LBP groups achieved 13.1° and 14.4° of rotation, respectively, compared to only 10.7° in the degenerative group. This decreased range of motion in LBP and degenerative patient groups was mainly evident during the extension phase of the activity. The coupled out-of-plane motions in both the LBP and degenerative subjects were significantly greater than those observed in healthy subjects (p<0.0199 and p<0.001, respectively) (Figure 2). On average, LBP and degenerative patients achieved 5.5° and 7.1° more out-of-plane rotational motion per level, respectively, compared to healthy subjects.

Discussion. These findings correlate with previous studies documenting paradoxical motions in the lumbar spine during an overall gross motion and support the idea of pain being a biological response to tissue injury which may result from excessive kinetic energy being introduced into the biological system from aberrant coupled motions. Identification of these irregular motion path magnitudes may aid in recognizing possible causes of pain in patients suffering from non-specific low back problems. Increased magnitudes of the out-of-plane rotational paths observed in symptomatic patients may also be an indicator for progressive pathologies requiring surgical intervention in the lumbar spine region.

Significance. The data derived in this study may serve as a foundation for a simple predictor of patient susceptibility for advancing progressive kinematic trends and future rehabilitative therapies by aiding in understanding which techniques best encourage re-stabilization of the lumbar spine structure following instances of low back pain.

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