

# **Preliminary Response Corridor for Combined Loading of the Lumbar Spine**

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## **Introduction**

In recent years, the installation of passenger seats at an angle offset from the direction of travel (oblique seats) has gained popularity with airplane manufacturers. Existing seat safety standards were not created specifically for oblique seats, so it is unknown whether current standards provide an appropriate level of protection for obliquely seated occupants. Previous Postmortem Human Surrogate (PMHS) tests have been conducted to investigate gross occupant kinematics in an oblique seating posture using the prescribed emergency landing test conditions set forth by the FAA. From this testing, severe lumbar spine injuries were produced through a combination of multi-axis bending and distraction. In an effort to better understand the loads associated with these injuries and how they differ from injuries in a forward facing seat, an experimental isolated PMHS spine study was created. The objectives of the study were to replicate the lumbar spine injury from the whole body test, and determine if there is a significant difference in load to failure between a flexed spine and an obliquely bent spine.

## **Methodology**

Seven PMHS isolated lumbosacral spines were tested in tension on an electrohydraulic piston while positioned in three separate postures: the spines naturally unloaded posture (neutral), flexed forward (flexed), and flexed and laterally bent 15° (oblique). With the sacrum fixed, a sub-failure tensile test to 4 mm of T12 displacement was conducted in each posture, followed by a tensile test to failure in the oblique posture (n=4) or flexed posture (n=3). Test specimens were isolated from T11/12 through the sacrum and were potted in Polymethyl methacrylate (PMMA). Both the T12/L1 and L5/S1 junctions were kept unrestricted. Retroreflective markers were used for motion analysis. Bolted to both the inferior and superior PMMA were 6 axis load cells. Force and moment data were collected. The inferior load cell was then attached to a novel positioning table, and the superior load cell was attached to the electrohydraulic piston. Using rigid body transformations, the inferior load cell data were transformed to anatomic loads at the center of the sacral end plate. Using the method developed by Lessley et al., a preliminary response corridor was created for the tensile force of the oblique failures.

## **Results and Discussion**

The oblique response corridor demonstrates a large difference when compared to the average tensile response in the flexed position as well as existing flexion-distraction injury literature. The upper bound of the corridor has a peak load and displacement of 4006 N at 13.24 mm. These values are 16% and 22% less, respectively, than the average peak load and displacement of the flexed position failures. While there is a difference in method of load application and location of load estimation, work by Neumann et al. investigating flexion-distraction injuries has shown an average tensile force of 5200 N for dynamic loading conditions of similar intensity. A comparison of the data will demonstrate the significant differences in flexed and oblique tensile loading. Data to be included are peak load differences and plots demonstrating load response variations between current and previous work.