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## Research paper

# Effect of orientation on measured failure strengths of thoracic and lumbar spine segments

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## ABSTRACT

Substantial research has been performed over many years to determine the compressive failure limits of spinal motion segments. However, the majority of studies have not considered the natural alignment of the spine, testing only for pure compression loads. This study tested 27 motion segments, ranging from the T6/T7 to L4/L5 levels, from 13 human cadaveric spines. The segments were oriented in either the neutral position, based on Harrison posterior tangent angles, or in-line axially. Load was applied at a low rate, reducing dynamic effects and in contrast to previous studies, until failure was observed. Force and deformation were measured during testing, with the normalized parameters of stress and strain calculated post-test. Failure forces, adjusted for bone mineral density, were found to decrease by 11% in lumbar segments when oriented while thoracic segment adjusted failure force also decreased by 4.5%. Similarly, orientation decreased failure stress by 12% for lumbar segments and increased it by 25% for thoracic segments. Some correlation was found between failure strength and bone mineral density. After testing, all segments were visually examined to determine the failure mode, and DXA and radiographic scans were performed. Oriented segments exhibited different fracture characteristics than non-oriented segments. The results indicate that segment orientation has a significant effect on failure strength, stress, and strain, and should be considered when determining appropriate load limits.

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## 1. Introduction

The mechanical properties of the human spine have been investigated for many years, with much of the research focused on the lumbosacral spine. Tolerance limits were

established for prevention of low back injuries based on earlier research (Jager and Luttmann, 1989; Waters et al., 1993). However, low back injuries still remain the single largest category of work related injuries, comprising 27% of non-fatal occupational injuries (Mital et al., 1999; BLS, 2006)

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