Cyclic Testing of the Human Lumbar Spine Motion Segments

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ABSTRACT

Determining the mechanical properties of the spine is a significant step in understanding the behavior of the spine under normal conditions. Although a limited amount of data for cyclic loading is currently available, the tests are not completely documented and the loads, spine segment positioning, and frequency are not representative of those typically found during normal activities. The purpose of this study is to develop an understanding of the relationship between loads and the development of fatigue failure in lumbosacral motion segments.

Two damage measures were considered in this research. Creep has been used previously as a damage measure for spinal tissue but only limited data has been collected. Energy dissipation is widely used in nonlinear mechanics as a damage measure, but has not been applied in spinal biomechanics and is proposed herein. In addition to the creep and energy dissipation data, complete cyclic stress-strain data were collected to quantify the material properties and how they change with accumulating damage.

Motion segments T10/T11, T12/L1, L2/L3 and L4/L5 were tested in two series. Series one applied a pure compression load quasi-statically in the neutral position. The load was increased and the specimen was observed to determine failure. The failure stress was used to define the loading in the next series of tests. Series two applied an axial preload of 450 N followed by cyclic combined compression and flexion. The load magnitudes were determined based on 50% of the failure stress as determined in the first series of tests. In order to simulate typical work conditions, the load was applied at two frequencies, 0.2 Hz and 0.1 Hz.

The differences in behavior for two loading frequencies are highlighted. In addition, quantitative information on damage prediction using creep and energy dissipation as measures was developed.