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BACKGROUND CONTEXT: Occupation is strongly correlated to low back pain (LBP). Specific occupational activities associated with low back pain include poor posture, whole body vibration, and repetitive lifting. These activities have a common link: they result in fatigue of the primary spinal extensor musculature. This fatigue may lead to increased intervertebral loading - a stimulus for disc degeneration. If true, this association could provide a vital connection between detrimental physical activities and LBP. However, the link between muscle fatigue and increased load across the disc space has never been quantified in vivo.

PURPOSE: The purpose of this study was to develop and test a wireless multi-axial force-sensing implant and large animal model of primary extensor muscle fatigue. Combined, these tools allow measurement of in vivo spinal forces during muscle fatigue to quantify changes in spine loading.

STUDY DESIGN/SETTING: In vivo large animal model.

METHODS: We developed a wireless force-sensing implant to function as a total disc replacement. The implant has distinct superior and inferior articulating components to allow for vertebral motion and the collection of multi-axial force data through wireless sensors, as shown in Figure 1. Analytical, experimental, and computational models were used to characterize the correlation between sensor strain and applied axial and shear forces. To develop the fatigue animal model, following IACUC approval, Alpine-Nubian cross-bred goats were anesthetized and needle electrical stimulation was employed bilaterally to repeatedly activate the splenius. A load cell was used to measure magnitude of neck extension force over time to monitor fatigue progression. Stimulation continued until the extensor force diminished to near zero. Using our instrumented implant and muscle fatigue model, we then measured the correlation between fatigue and interbody force.

RESULTS: Measured forces were compared to applied loads in the force sensing implant to validate the analytical model. The experimental and computational loads were within 4% and 1% error, respectively. In the animal model, maximum contraction of the splenius was obtained from a stimulating frequency of 1 Hz with a 200 msec duration and an amplitude of 300 V. The baseline neck extension force was 37 N and decreased linearly to less than 5 N over 2 hours.

CONCLUSIONS: Our results demonstrate that the implant is sufficiently sensitive to measure axial and shear forces in vivo and that our technique for low frequency primary extensor muscle fatigue is repeatable, with a linear decrease in force. These tools can be used to quantify axial and shear interbody forces and their correlation to muscle fatigue. This will facilitate characterizing the role of muscle fatigue in disc degeneration and elucidate a possible mechanism through which everyday activities lead to LBP.

FDA DEVICE/DRUG STATUS: This abstract does not discuss or include any applicable devices or drugs.