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Development of a Cartesian biomechanical testing system with 6DOF coordinated real-time load control: Application to the lumbar spine (L1-S, L4-L5)

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In-vitro robotic biomechanical assessments of human joints offer more comprehensive evaluations however standard position control algorithms make real-time load control problematic. To better simulate in-vivo multi-directional load conditions we report on development of a Cartesian load controlled testing system (CLTS) with coordinated real-time load control. A custom 6 degree of freedom (DOF) manipulator with cascaded force over position control algorithms was assembled. Dial gauge tests assessed accuracy of linear axes. Standard test input and tuning procedures refined control performance. Two lumbar (L4-L5) and (L1-S) spine segments were tested in flexion-extension, lateral bending and axial rotation to 8Nm under full 6-DOF load control. L4-L5 specimens were tested with force components dynamically programmed to deliver a resultant 400N follower load that remained normal to the moving midline of the intervertebral disc. Mean tracking errors between commanded and experimental loads were computed. Spinal rotations were compared to published values for non-robotic protocols. Individual linear and rotational axis position control accuracies were less than 6.35 µm and 0.0167° respectively. Pilot tests demonstrated stable control performance, as well as load rates, rotational velocities, and ranges of motion comparable to those for standard non-robotic *in-vitro* tests. Tracking errors for force and moment controlled axes were less than 1.3±1.6 N and 0.18±0.19 Nm, respectively. The CLTS simplified application and demonstrated robust position and load control that was not limited to single axis or zero-commanded loads. The CLTS is a promising tool for biomechanical assessments with coordinated dynamic load application and coupled motion response in 6DOF.

Biography

Brian P Kelly received his Doctorate from the University of Tennessee Health Science Center (UTHSC) in 2005 and is currently an Assistant Professor of Biomedical Engineering at UTHSC. He has been the Principle and Co-Investigator of more than 20 industry sponsored research studies, the author/co-author of more than 11 published journal articles and 63 published conference abstracts, and presented more than 16 invited oral podium presentations at seminars and conferences. He is currently a reviewer for several reputed journals, and serves as theme leader/organizer for joint and spine biomechanics sessions at the ASME Annual Summer Bioengineering Conference.

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