Effects of Muscle Activation on Occupant Kinematics in Frontal Impacts

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Continued development of computational models and biofidelic anthropomorphic test devices (ATDs) necessitates further analysis of the effects of muscle activation on an occupant's biomechanical response in car crashes. In this study, a total of 28 dynamic sled tests were performed, 14 low (2.5g, Δv=4.8kph) and 14 medium severity (5.0g, Δv=9.7kph), with 5 male human volunteers (approximately 50th percentile male height and weight) and a Hybrid III 50th percentile male ATD. Each volunteer was exposed to 2 impulses at each severity, one relaxed and the other braced prior to the impulse. The ATD was subjected to 4 impulses at each severity. A 172 channel onboard data acquisition system was used to record subject head accelerations, spine accelerations, chest contour, surface electromyography of 20 muscles (legs, arms, abdomen, back, and neck), and forces at each interface between the subject and test buck at a sampling rate of 20kHz. A Vicon motion analysis system, consisting of 12 MX-T20 2 megapixel cameras, was used to quantify subject 3D kinematics (±1mm) at a sampling rate of 1kHz. The excursions of select anatomical regions were normalized to their respective initial positions and compared by test condition across subjects. At the low severity, bracing significantly reduced ($p<0.05$) the forward excursion of the lower extremities (50%), pelvis (60%), upper extremities (35-70%), and head (47%). At the medium severity, bracing significantly reduced ($p<0.05$) the forward excursion of the upper extremities (63-69%) and the head (36%). Although not significant, bracing at the medium severity considerably reduced the forward excursion of the lower extremities (18-26%) and pelvis (22-25%). Data indicates that loads were distributed through the feet, seatpan, and steering column as opposed to the seatbelt for the bracing condition. This study illustrates that muscle activation has a significant impact on the biomechanical response of human occupants in front impacts.