Effects of Chestbands on the Global Response and Localized Loading in the Human Thorax

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Abstract

Chestbands are commonly used in injury biomechanics as an instrument to measure the contour of the thorax throughout impact, from which chest deflection may be calculated. There exists a concern that by tightly wrapping a chestband, or especially multiple chestbands, around the thorax of a subject, the thorax characteristics and impact response will be altered. Of particular concern are the effects on small, frail subjects, as their low mass and low bone strength could amplify potential chestband effects. The objective of this study was to evaluate the effects of chestbands on the thoracic response of a small, frail post mortem human subject (PMHS) in frontal impact.

In order to evaluate the effects of chestbands, a series of low-velocity frontal impacts were applied to one PMHS using a 23 kg pneumatic ram. The subject was placed on a fixture with a vertical, rigid seat back to prevent spinal motion during the impact, thus enabling the ram displacement to be used as a consistent measure of chest deflection for all impacts. A baseline impact scenario of 0.8 m/s impact velocity with no chestbands present was tested first, then repeated intermittently throughout testing. Deviations from the baseline scenario were systematically applied, including adjustments to impact velocity and to chestband status (the number of chestbands present on the subject during impact). Impact velocities were 0.8 m/s, 1.0 m/s, 1.5 m/s, and 2.0 m/s. Chestband status was 0, 1, or 2 chestbands. Eighteen total impacts were applied to the subject, including every combination of impact velocity and chestband status except for the scenario of 2.0 m/s with no chestbands because rib fractures had occurred prior to testing that scenario.

The evaluation of chestband effects was divided into global response, described by the chest deflection, and localized loading differences, described by rib strain. A 6 degree of freedom motion block was placed on T4 to verify that there was no spinal motion, and to provide a correction in the event of spinal motion occurrence. Data to be presented includes chest deflections, force-deflection curves, thorax stiffness, rib strains and strain rates.

Results show no systematic variation in deflection, force-deflection, or stiffness based on chestband status. Rib strains and strain rates show a trend of increased strain (+2%) and strain rate (+5%) for the ribs in contact with a chestband, while decreasing strain (-20%) and strain rate (-23%) in a non-contacted rib when comparing two tests of the same impact speed, with and without a chestband. The results suggest that chestbands could have a negligible effect on global

response of the thorax to impact, but that chestbands may alter the observed injury pattern as a result of changing the load distribution. It is recommended that additional investigation into localized loading from chestbands be pursued. These conclusions advance the field of injury biomechanics by 1) providing evidence that chestbands do not alter global thoracic response, which has previously been merely assumed and 2) identifying a need for future investigation into load redistribution by chestbands.

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University where research was completed	*The Ohio State University*
Department/program	*Mechanical & Aerospace Engineering Department*
Degree sought during work done for Symposium paper	*Ph.D.*
Student's start/completion date of degree	*August 2013 – May 2017*
Name of student's advisor	*John H. Bolte IV*
Poster or oral presentation preference	*Oral*

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