Kinematics of the THOR-50M-RS in an Upright Frontal Sled Impact with a Simplified Restraint Environment

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I. INTRODUCTION

Anthropometric test devices (ATDs) are used to assess automotive safety systems. The Test device for Human Occupant Restraint 50th percentile male (THOR-50M) ATD has been modified for reclined seating (THOR-50M-RS). Modifications include changes to the pelvic flesh, abdomen, and spine flex joints [1]. The THOR-50M-RS has an additional flex joint in the lower thoracic spine which replaces the Lumbar Spine Pitch Change Assembly in the THOR-50M. The goal of this study is to compare the spine motion of the THOR-50M-RS to the THOR 50M in an upright frontal sled impact with a simplified restraint environment, the "Gold Standard 1" (GS1) condition [2].

II. METHODS

The test condition in this study was a full-frontal impact in the previously published GS1 condition [2]. The test fixture consists of a rigid seat, knee bolster, and footrest designed to limit the forward excursion of the lower extremities and pelvis to isolate the thoracic response. The restraint system used in this condition was a three-point seatbelt with separate shoulder and lap belt segments and with the shoulder-belt fixed at the D-ring (no pre-tensioner and no force-limiter). A reverse acceleration sled was used in all tests to achieve a trapezoidal pulse of 14g with a delta-V of 40 kph. Each ATD was positioned to match previous tests of post-mortem human subjects (PMHS) with emphasis on matching H-point location and gross posture of the torso [2]. Four tests of the THOR-50M-RS were conducted in this study and were compared to three tests of the THOR-50M [3].

Rigid arrays of motion capture markers were attached to rigid segments on each ATD to capture the kinematic response of the ATD using a 3D-motion tracking system (Vicon TX^{TM}, Oxford, UK). Arrays were attached to the head, upper thoracic spine, lower thoracic spine, lumbar spine (for the THOR-50M-RS), and pelvis. Using the locations of the measured motion tracking markers, the positions of pseudo-anatomical landmarks were calculated using the method published by Parent *et al.* 2012 [4]. The pseudo-anatomical locations in reference to the local coordinate systems of the spine of the THOR-RS can be seen in Figure 1. The use of pseudo-anatomical landmarks in this method allows for a better comparison between the THOR-50M-RS and the THOR-50M due to the differences in the spine.

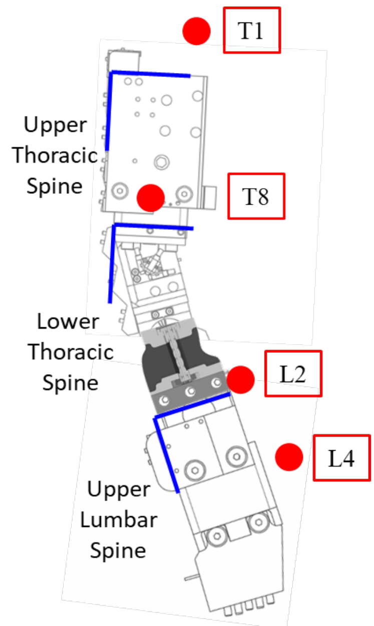

Fig 1. Average approximate anatomical landmarks on the spine from PMHS tests (red) overlaid on the spine of the THOR-50M-RS in the same seated position. Local coordinate systems of each rigid segment in blue.

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III. INITIAL FINDINGS

The trajectories of the motion of the THOR-50M-RS in the impact are shown in Figure 2 as 2D projections in the sagittal plane. The trajectories of the motion of previous THOR-50M GS1 testing are plotted alongside the THOR-50M-RS for comparison [3].

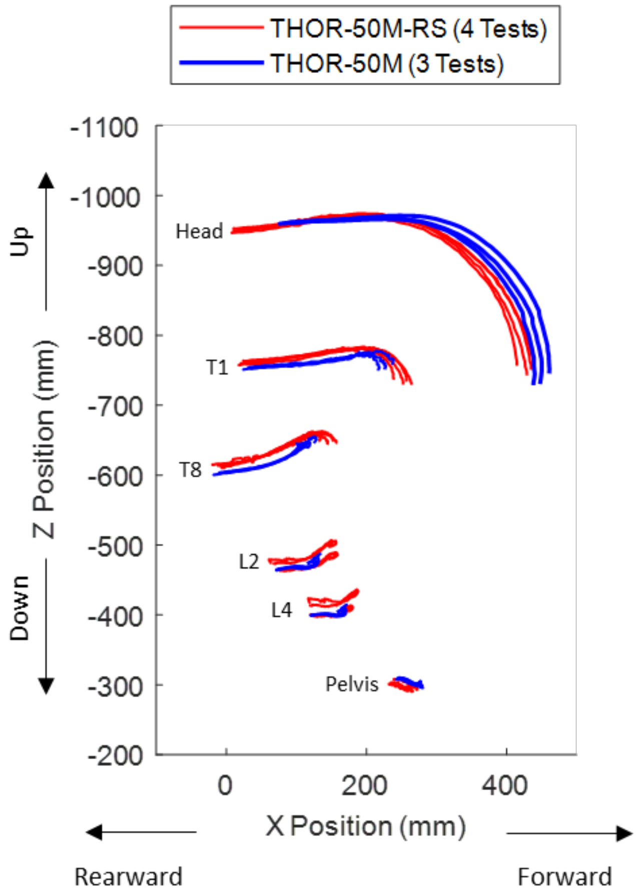

Fig 2. Sagittal projection of the THOR-50M-RS and THOR-50M.

IV. DISCUSSION

Overall motion of the THOR-50M-RS and THOR-50M was similar but differences in local motion of the spine were observed. The figure shows expected small differences in initial position between the two ATDs, most notably at the head. The THOR-50M has a lumbar pitch change joint assembly, which dictates a 12° angle ("super-slouched") between the lumbar and lower thoracic spine segments where the THOR-50M-RS has a lumbar flex joint. The lumbar flex joint of the THOR-50M-RS has an undeformed flexion angle of 4°. Since both ATDs were positioned to match the gross torso posture of the PMHS, the upper spine of the RS was more extended, which puts the initial position of the head slightly rearward.

Despite similarity in the overall motion of the ATDs in this condition, the THOR-50M-RS showed a higher degree of spinal flexion than its unmodified counterpart. At T1, the difference is indicated by a tighter curve after peak excursion in the THOR-50M test series. A similar trend of motion can be seen at T8. For the landmarks calculated at L2 and L4, previous testing calculated the trajectories using the rigid array mounted to the pelvis. In this study, the extra pitch joint creates an additional rigid body so the L2 and L4 can be calculated from a rigid array attached to the lumbar segment of the spine. The motion of the lumbar spine landmarks shows a different overall trajectory in the THOR-50M-RS compared to the THOR-50M. The difference between the trajectories of the lumbar landmarks is because of the difference in calculation. Due to the rigid coupling of the lower extremities in this condition, the pelvis motion for both ATDs is similar.

The THOR-50M has been compared to PMHS in this condition [5]. Future work will compare the THOR-50M-RS to PMHS.

V. ACKNOWLEDGEMENTS

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VI. REFERENCES

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