# Preliminary Comparison of Maximum External Chest Deflection Locations between Small Female PMHS and ATDs during Frontal Sled Tests

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## I. INTRODUCTION

Anthropomorphic test device (ATD) design has historically focused on the 50th percentile male. However, there is evidence that females might respond differently in motor vehicle collisions (MVC) compared to males [1-3]. The THOR 5th percentile female ATD (THOR-05F) has recently been developed as an effort to improve upon the Hybrid III 5th percentile female ATD (HIII-05F). There are major differences in the chest flesh design between the two ATDs, which can have a substantial effect on chest response to belt and airbag forces [4]. Critically, the location of maximum deflection could be influenced, which would influence the chest deflection measured by the internal instrumentation in the ATDs. Previous studies have evaluated differences in internal deflection between the two ATDs, but external deflections were not compared between the ATDs or to the responses of post-mortem human subjects (PMHS) [5-7]. The authors of the current study have previously compared the locations of maximum external deflection (maxDef) of the THOR-05F and HIII-05F ATDs using chestbands [8]. However, matched tests using PMHS were not yet conducted. The objective of this study was to compare the locations of maxDef measured during matched frontal sled tests between small female ATD tests and recently conducted PMHS tests.

## II. METHODS

A 7th-generation Toyota Camry driver seat test buck was used with Camry parts (i.e., 3-point belt, modified seat, steering wheel, 2-stage airbag, and steering column) [8]. The belt was equipped with a 4-kN load limiter and retractor pretensioner. Rigid foam (65 psi) was used for the knee bolster. Four HIII-05F tests, three THOR-05F tests, and one PMHS test were conducted using a 56 kph sled pulse (47 G). Three HIII-05F tests, three THOR-05F tests, and two PMHS tests were conducted using a 30 kph sled pulse (23 G), scaled from the 56 kph pulse.

Two chestbands were used to measure external chest deflections during the ATD and PMHS tests. The target locations for applying the chestbands on the anterior chest were the midpoint between ribs 3 and 4 for the upper chestband, and the mid-xiphoid process for the lower chestband. For the ATDs, the translation of these points onto the ATD structures, locations of internal chest deflection instrumentation, and chest flesh/jacket geometries were considered when choosing the final positions for the chestbands. For the HIII-05F, the chestbands were placed at the level of rib 1 and between ribs 4 and 5. For the THOR-05F, the chestbands were placed between the anterior aspect of ribs 2 and 3 and slightly above the anterior aspect of rib 5 [8]. For the PMHS, differences in seated height, the location of instrumentation on the spine, and breast location all influenced where the chestbands were placed on the PMHS. The lower chestband was placed directly inferior to the breasts, such that the breast tissue typically rested over the band. The upper chestband was placed superior to the bulk of the breast tissue, but as close to the target location as possible. For the PMHS, the vertical positions of the chestbands, the xyphoid process, and shoulder belt edges are reported relative to the sternal notch in Table I.

For each chestband, 2D contours were generated at 1 ms increments using the curvature data and RBandPC software (Conrad Technologies). Chord deflections were calculated using anterior-posterior point pairs that were spaced at 1 mm increments for each chestband. The peak deflection of all pairs was compared to find the medial-lateral (ML) location of maxDef for each chestband.

TABLE I
CHEST CIRCUMFERENCES AND VERTICAL DISTANCES FROM THE STERNAL NOTCH TO PARAMETERS OF INTEREST (MM)

| Test | Upper Circ. | Lower Circ. | Upper Chestband | Lower Chestband | Superior Xyphoid | Inferior Xyphoid | Upper Belt Edge | Lower Belt Edge |
|---|---|---|---|---|---|---|---|---|
| *PMHS 30-1* | 790 | 797 | 41 | 172 | 122 | 154 | 49 | 126 |
| *PMHS 30-2* | 781 | 756 | 97 | 162 | 166 | 197 | 50 | 125 |
| *PMHS 56-1* | 748 | 786 | 66 | 196 | 150 | 186 | 50 | 130 |

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## III. INITIAL FINDINGS

The ML locations of maxDef relative to the sternum for the upper and lower chestbands are shown in Fig. 1. Both absolute ML locations and ML locations normalised by chest breadth at the level of the chestband are presented. The locations of maxDef approximately follow the path of the shoulder belt, near the sternum for the upper chestband, and to the right of the sternum for the lower chestband. For the lower chestband on the PMHS, the location of maxDef for the 56 kph test was further right compared to the 30 kph tests. The location for the lower chestband was further to the right of the sternum for the THOR-05F compared to the HIII-05F. The lower chestband maxDef location for the THOR-05F was closer to the PMHS location compared to the HIII-05F. The locations of maxDef were more consistent for the HIII-05F compared to the THOR-05F on both chestbands.

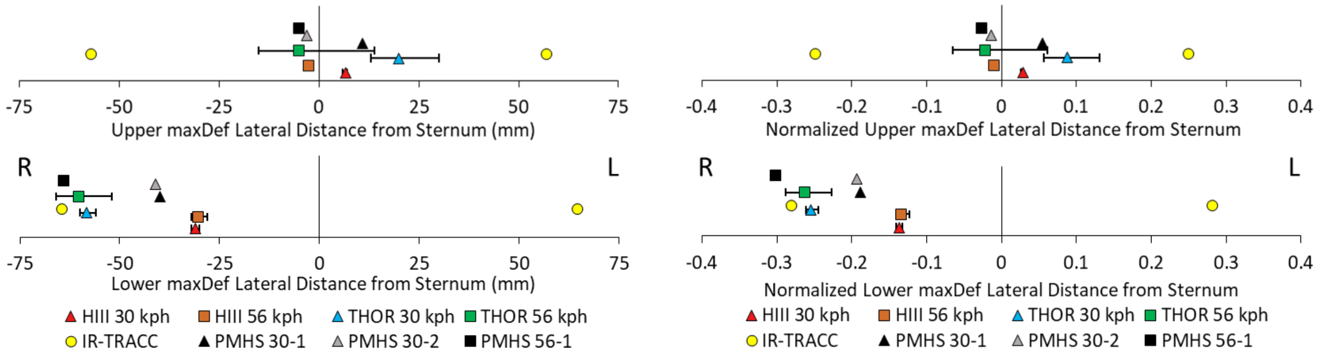


Fig. 1. Absolute (left) and normalised by chest breadth (right) ML locations of the maxDef measured by the upper and lower chestbands. Error bars represent data range.

## IV. DISCUSSION

When comparing the locations of maximum external deflection between surrogates, it is important to consider that the location of maximum internal deflection might be different. Compression of material external to the rib cage can influence the location of external deflection relative to internal deflection. For the PMHS, it is possible that the external deflections at the upper chestband are more influenced by the breast tissue compared to the lower chestband deflections based on band placement. The ATD jackets also have compressible material external to the rib cage that can possibly influence the external deflections, which has been previously discussed [8].

The location of maxDef for the upper chestband occurred near the sternum for all surrogates; however, the ML location of maxDef for the THOR-05F varied more than the HIII-05F and the PMHS. This could suggest that the HIII-05F has greater repeatability and better matches the PMHS maxDef location. The internal sternum chest potentiometer in the HIII-05F is closer to the location of maxDef at the level of the upper chestband compared to the THOR-05F and might better capture the location of the peak internal deflection at the upper chest under these loading conditions. However, the true peak internal deflection location for the PMHS is not known.

For the lower chestband, the locations of maxDef in the PMHS tests were closer to the THOR-05F maxDef locations compared to the HIII-05F. The maxDef locations in the PMHS tests were also closer to the equivalent location of the THOR lower right Infra-Red Telescoping Rod for the Assessment of Chest Compression (IR-TRACC) compared to the HIII-05F chest potentiometer. The maximum internal deflection occurred at the lower right IR-TRACC in the THOR-05F 30 kph, which suggests that the THOR-05F might better capture the location of maxDef at the lower chestband level under these loading conditions.

In conclusion, the upper chestband maxDef locations suggest that the HIII-05F might better capture the maximum deflection of the PMHS with the chest potentiometer while the THOR-05F IR-TRACC might better capture the maximum deflection at the lower chest under these loading conditions. However, the actual peak internal deflection location is uncertain in these PMHS tests. More PMHS tests will be conducted with these conditions to allow for further analysis.

## V. REFERENCES

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