# Behavior of Variant Human Body Models on Different Restraint Systems with the Aid of ANSA HBM Toolset

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## Abstract

Restraint systems have traditionally been developed based on the anthropometric characteristics of the average male, potentially reducing safety for individuals with different body proportions. Expanding simulations coverage to a wider range of body types is essential, but current Human Body Models (HBMs) lack high anthropometric diversity due to the high cost and time required for development. To address this limitation, this research introduces the HBM Scaling Tool designed to adapt existing HBMs to variant anthropometric profiles. A comparative analysis is carried out between two human body models (HBMs) defined using LS-DYNA keywords: the baseline THUMS AM95 and a THUMS AM50 model scaled to AM95 anthropometrics using the Scaling Tool. The comparison focuses on multiple criteria, including mass distribution, center of gravity (COG), body morphology, bone dimensions, and elements quality. The scaled model validation involves conducting sled test simulations with various restraint systems, meticulously configuring LS-DYNA keywords for accurate testing. These simulations are closely modeled after Vezin et al.'s (2001) study. Acceleration in the head, spine, and pelvis—are analyzed, along with major principal strain patterns in the ribs. The results are compared with those from the original THUMS AM95 model and available experimental data from the Vezin study. This research highlights how the proposed scaling approach enables more representative occupant simulations, supporting the development of restraint systems that are better suited to a diverse population.

## 1 Introduction

Current restraint systems are predominantly optimized around the 50th-percentile male, which can limit protective performance for occupants with different anthropometry. To broaden safety coverage without incurring prohibitive model development costs, we investigate an efficient scaling approach that adapts an existing HBM to alternative body sizes while preserving mesh integrity and connectivity.

## 2 Methods

We used the baseline THUMS AM95 v6.1 and a THUMS AM50 v6.1 scaled to AM95 anthropometrics with the ANSA HBM Scaling Tool. The scaling workflow followed Landmarks → Segments → Sections, where targets drive external surface scaling while internal parts (bones, organs, muscles) morph consistently, preserving element count as well as tissue connectivity and mesh continuity. Anthropometry targets were derived from ANSUR via PIPER metadata, with support for LS-DYNA and PAM-CRASH formats. Positioning was performed with the ANSA Articulation Tool, and restraints were routed and adjusted using the ANSA Seatbelt Tool. Validation sled tests used a rigid seat, a 3-point belt, and no airbag; ΔV ≈ 50 km/h (R44-03 pulse), belt force limiters of 4 kN and 6 kN; and history nodes at the Head COG, T1, T8, and Pelvis.

## 3 Results

**<u>Models comparison:</u>**

• Mass/COG & Shape: AM95 = 106.3 kg; Scaled-AM95 = 102.7 kg (COG nearly identical).

• Bone dimensions: Differences within ~1–19% across ribs, vertebrae (C3/L3), sternum, humerus, hipbone, and femur.

• Mesh quality: Off-shell elements—aspect ratio +13% and skewness +28% for Scaled-AM95; Off-solid elements—aspect ratio −5%; wrapping/Jacobian unchanged; no new intersections.

**Sled test validation:**
• Kinematics: Similar trajectories and accelerations (Head COG, T1, T8, Pelvis) for both belt force limiters; overall comparable occupant motion.
• Injury metrics: Major principal strain distributions on ribs show pattern differences; qualitative correlation with Vezin (2001) fracture locations.

## 4 Discussion

The scaling approach produced an AM95-equivalent human model from an AM50 baseline while preserving topology and mesh continuity. Observed differences in mass distribution and localized abdominal geometry influenced rib strain patterns, especially under different belt force limiters. Nevertheless, the overall kinematic response and acceleration time histories between the baseline AM95 and Scaled-AM95 remained broadly comparable, supporting the validity of the scaling methodology for occupant injury risk studies across anthropometric variants.

## 5 Conclusions

The ANSA HBM Scaling Tool efficiently generates anthropometric variants without re-meshing, enabling rapid iteration while preserving model integrity. Across our evaluations, the scaled models retained kinematics and overall system response comparable to baseline references, supporting the approach's validity. At the same time, localized morphology—such as increased abdominal fat—can meaningfully alter rib-strain patterns, indicating these features should be explicitly parameterized and explored. Overall, the method facilitates broader, more inclusive restraint-system development across diverse body types.

## 6 Summary

We compared a baseline THUMS AM95 against an AM50 scaled to AM95 using the ANSA HBM toolset across mass/COG, morphology, bone measures, mesh quality, sled-test kinematics, and rib strain. Results indicate close kinematic agreement and notable local strain differences due to morphological factors, reinforcing the value of scalable anthropometric modeling for inclusive restraint design.

## 7 Literature

[1] Vezin, P., et al.: “Sled test study on rib fracture mechanisms,” 2001.