February 27, 2025

Cem Hatipoglu
Associate Administrator, Vehicle Safety Research

National Highway Traffic Safety Administration
1200 New Jersey Avenue, SE
Washington, DC 20590

Title: Occupant Anthropometry and Seating, NHTSA Docket No. 2024–0056 (December 30, 2024)

Dear Cem Hatipoglu,

The Partnership for Dummy Technology and Biomechanics (PDB) highly appreciates the intension of NHTSA to update fundamental anthropometric data. We would like to take the opportunity to comment the published plan.

If there are questions, please contact me by email (christian.gehre@pdb-org.com) or by phone (+49 841 89 91276).

Sincerely,

Dr. Christian Gehre
(Managing Director)

Occupant Anthropometry and Seating, NHTSA Docket No. 2024–0056

1 General remarks

This study is highly interesting as it updates and expands reference anthropometry and seating data for ATDs and Human Body Models (HBMs). Additionally, it is also relevant for addressing equitability in occupant protection and offers valuable insights into how occupant position changes during driving.

2 Study design

- The body sizes should represent the overall population. However, a sufficient number of participants should align with the current characteristic percentiles (5^{th}, 50^{th} and 95^{th} for male and female). This ensures an effective evaluation of how well existing dummies represent updated anthropometric data and informs future dummy designs.
- The second-row seat position could be included alongside the driver and passenger positions.
- Age should be considered alongside anthropometry, as it influences seating position.
- For the in-vehicle study, measurements should be conducted at a consistent time of day, preferably in the morning, to minimize the effects of spine relaxation due to daily activities.

3 Laboratory study

The proposal lacks details on the measurements to be conducted in the study beyond the 3D scan data. While 3D scan data are valuable for the positioning and anthropometrical evaluation of dummies and HBM, they are not sufficient on their own. Bone positions are also essential for this endeavor. We assume that the measurements conducted in the first AMVO study [1] will be replicated in this study, at least in the seating mockups. In the AMVO study, various body dimensions were recorded, along with the positions of landmarks (Figure 1, Figure 2).

TABLE H.1

INDEX TO HARDSEAT MEASUREMENTS

Measurement
Sitting Height
Cervicale Height
Chin Height
Neck Length (anterior)
Neck Breadth (mid)
Neck Depth (mid)
Neck Circumference (mid)
Neck Breadth (lower)
Neck Depth (lower)
Neck Circumference (lower)
Shoulder Height (mid)
Acromion Height
Clavicale-to-Acromio-Clavicular Articulation
Shoulder Breadth
Shoulder Circumference
Biacromial Breadth
Torso Depth (upper)
Shoulder Depth (scye)
Axillary Depth
Arm Angle (upper)
Arm Angle (lower)
Right-Left Medial Humeral Epicondyle
Right-Left Stylion
Arm Circumference (scye)
Arm Breadth (upper)
Arm Depth (upper)
Arm Circumference (upper)
Arm Breadth (above elbow)
Arm Depth (above elbow)
Arm Circumference (above elbow)
Olecranon Height
Elbow Breadth
Elbow Depth
Elbow Circumference
Forearm Breadth (upper)
Forearm Depth (upper)
Forearm Circumference (upper)
Forearm Circumference (lower)
Wrist Breadth (condyles)
Wrist Depth (condyles)
Wrist Circumference (condyles)
Chest Height (nipple)
Chest Height (posterior scye)
Chest Breadth (axilla)
Chest Circumference (axilla)
Chest Breadth (nipple)
Chest Circumference (nipple)
Chest Circumference (tenth rib)
Waist Breadth (umbilicus)
Waist Depth (umbilicus)
Waist Circumference (umbilicus)
Abdominal Breadth (maximum)
Abdominal Depth (maximum)
Abdominal Circumference (maximum)
Iliocristale Height
Thigh-Abdominal Junction Height
Anterior-Superior Iliac Spine Height
Trochanterion Height
Hip Breadth (maximum)
Bitrochanter Breadth
Leg Angle (upper)
Leg Angle (lower)
Right-Left Medial Femoral Epicondyle
Right-Left Sphyrion
Trochanter-To-Lateral Femoral Condyle
Thigh Breadth (upper)
Thigh Circumference (upper)
Thigh Breadth (mid)
Thigh Circumference (mid)
Knee Height
Knee Breadth
Knee Depth (popliteal)
Knee Circumference
Calf Breadth
Calf Depth
Calf Circumference
Ankle Breadth (minimum)
Ankle Depth (minimum)
Ankle Circumference (minimum)
Ankle Breadth (condyles)
Ankle Depth (condyles)
Ankle Circumference (condyles)

Figure 1: AMVO body dimensions measurements.

TABLE K.1
LIST OF SURFACE LANDMARKS

Body Region	Ref. No.	Landmark Name
Head and Neck	1	Glabella
	2	Infraorbitale
	3	Tragion
	4	Gonion
	5	Gnathion
Spine and Scapula	7	Cervicale (C7)
	8	T4
	9	T8
	10	T12
	11	L2
	12	L5
	13	10th Rib, Mid-Spine
	14	Scapula, Superior Margin
	15	Scapula, Inferior Margin
Chest and Torso	18	Suprasternale
	19	Mesosternale
	20	Substernale
	21	Bimammary Midline
	22	Nipple
	23	10th Rib, Anterior Midline
	24	Umbilicus
	25	Maximum Abdominal Protrusion
	26	10th Rib
Pelvis and Hip	27	Iliocristale
	28	Anterior-Superior Iliac Spine (ASIS)
	29	Symphysion (Pubic Symphysis)
	30	Thigh-Abdominal Junction
	31a	Trochanterion (palpated)
	31b	Trochanterion (skeletal reconstruction)
Shoulder	33	Clavicale
	34	Acromio-Clavicular Articulation
	35	Greater Tubercle Humerus
	36	Acromion
	37	Scye, Anterior
	38	Scye, Posterior
Arm and Hand	39	Lateral Humeral Epicondyle
	40	Radiale
	41	Medial Humeral Epicondyle
	42	Olecranon
	43	Ulnar Styloid
	44	Stylion
Leg and Foot	**45**	**Lateral Femoral Condyle**
	46	**Medial Femoral Epicondyle**
	47	**Tibiale**
	48	**Patella**
	49	**Sphyrion**
	50	**Metatarsal/Phalangeal I**
	51	**Digit II**
	52	**Metatarsal/Phalangeal V**
	53	**Lateral Malleolus**
Anthro. Measurement Points	**93**	**Neck, Mid**
	94	**Neck, Lower**
	95	**Arm, Upper**
	96	**Forearm, Upper**
	97	**Forearm, Lower**
	98	**Thigh, Upper**
	99	**Thigh, Mid**
	100	**Calf**
	101	**Ankle**

Figure 2: AMVO list of bony landmarks.

The landmarks can be used to position and orient HBM bones, and they should be chosen, if possible, to allow for direct calculation of commonly used angular measures. Generally, more landmarks are preferable, but below is a list of important landmarks, which we consider the minimal requirement.

Table 1: Minimal List of landmarks for HBM positioning.

Bone structure	**Positioning target**	**Landmarks**	**AMVO Ref. No. [Figure 2]**
Skull	COG Angle (Ex: Frankfurter plane)	Infraorbitale Tragion	2 3
Spine	Curvature of the lumbar, thoracic, and cervical spine	At least 3 interpolation points per region (lumbar, thoracic, and cervical) are necessary. Two points at the upper and lower end of the segment and at least 1 in the middle. Transition vertebrae (C7/T1, T12/L1) can be used for both segments that they link, meaning that there is, for example, no need to measure both C7 and T1. For the Thoracic region, 4 landmarks may be necessary.	N/A
Chest	Sternum position and angle	Suprasternale Substernale	18 20
Shoulder	Clavicle, humerus, and scapula positions	Clavicale Acromio-Clavicular Articulation Greater Tubercle Humerus Acromion Scapula Inferior Angle (if palpable) Scapula Superior Angle (if palpable)	33 34 35 36 N/A N/A
Pelvis	H-point PS-ASIS Angle Pelvic notch angle	Iliocristale ASIS PS Trochanter (proxy for H-point) AIIS (if palpable)[1]	27 28 29 31 N/A
Arm and hand	Elbow and wrist positions	Lateral Humeral Epicondyles Medial Humeral Epicondyle Ulnar Styloid Stylion	39 41 43 44
Leg and foot	Knee, ankle, and foot positions	Femoral Condyle Patella Digit II Lateral Malleolus Pternion (posterior point on the heel)	45 48 51 53 N/A

We recommend measuring the belt routing in the mockup configuration. Belt routing is heavily influenced by the position of the D-ring and belt anchoring points in specific car models, an analysis is needed to ensure that their placement is representative. The belt's relative position to bony parts must be properly documented.

The description of the study does not specify whether reclined seating positions will also be measured. Generally, seating data for reclined positions remain relatively scarce, and additional data are needed for various seat pan and seat back angles. However, we recommend ensuring enough data for seatback angles (SAE torso angles) around 45° to 50°, as these angles are more likely to be included in near-future regulatory and consumer testing.

[1] Needed for measurement of pelvic notch angle

4 In-vehicle study

- Whenever possible, the landmarks measured in the laboratory study should also be measured in the vehicle. However, some, such as the spine, may not be measurable. Additionally, the belt routing would be a very valuable measurement.
- Before taking measurements with the volunteers, we recommend using the FMVSS 208 [2] procedure to establish a consistent coordinate system in each car and conduct relevant interior measurements (e.g. D-ring, steering wheel). All subsequent measurements (e.g. body landmarks, belt routing) should then be taken in the previously defined coordinate system. We recommend measuring the position of the rotation axis of the seat back additionally.
- If possible, volunteers should be statistically measured before the driving. To ensure reproducibility, a first static measurement could be conducted with standardized seating parameters (e.g. seat back angle, headrest position), possibly following existing procedures (e.g. NHTSA THOR-50M [3]), and with instructions given on how to properly position the seatbelt. In a second static measurement, volunteers could be allowed to seat in a comfortable position with the freedom to adjust all the seat parameters, the adjusted seating parameters should be measured possibly using the SAE-Manikin. Of particular importance is the relative position of the pelvis, seat, and belt.
- Please consider measuring the pressure distribution on the seat pan during static measurement (standardized seating, comfortable seating, if applicable also reclined).

5 References

[1] Schneider, L., Robbins, D., Plüg, L., & Snyder, R. (1983). *Anthropometric specifications for mid-sized male dummy* (Report No. UMTRI-83-53-1). University of Michigan Transportation Research Institute (UMTRI). Prepared for the National Highway Traffic Safety Administration (NHTSA).

[2] National Highway Traffic Safety Administration. (2025). *49 CFR § 571.208 - Standard No. 208; Occupant crash protection*. Code of Federal Regulations. Retrieved from https://www.ecfr.gov/current/title-49/subtitle-B/chapter-V/part-571/subpart-B/section-571.208

[3] Louden, A. (2019). *Revised THOR 50th Percentile Male Dummy Seating Procedure*. Report No. DOT HS 812 746). Washington, DC: National Highway Traffic Safety Administration.