UNIVERSITY of VIRGINIA
SCHOOL of ENGINEERING & APPLIED SCIENCE
Department of Mechanical and Aerospace Engineering

Jason R. Kerrigan PhD
Director
Center for Applied Biomechanics
Associate Professor
Department of Mechanical and Aerospace Engineering
Department of Orthopaedic Surgery
University of Virginia

March 16, 2020

DI Werner Leitgeb
OSCCAR Project Coordinator
VIRTUAL VEHICLE Research Center
Inffeldgasse 21A, 8010 Graz, AUSTRIA

RE: Positioning Data for Human Body Models in Reclined Seating

Dear Mr. Leitgeb,

As we understand it, the OSCCAR project aims to develop a novel simulation-based approach to safeguard occupants involved in future vehicle accidents. It is with great pleasure that we write today to offer to share some data to help standardize assessments of human body models (HBMs) in reclined occupant frontal crash tests.

As you may be aware, our team at the UVA Center for Applied Biomechanics, in collaboration with and with support from Autoliv Research, has performed some reclined occupant frontal crash sled tests using mid-sized male post mortem human surrogates (PMHS). These tests were performed to investigate the biomechanical response of reclined vehicle occupants subjected to frontal crash and to evaluate restraint countermeasures aimed at protecting reclined occupants. Information about the methods used to perform these experiments was first presented at the 26th International Technical Conference on the Enhanced Safety of Vehicles (ESV) in Eindhoven, The Netherlands, in June of 2019 (Richardson et al. 2019). This year, we are planning three additional publications:

- Richardson et al. 2020, AAAM/Traffic Injury Prevention: Thoracolumbar spine kinematics and injuries in frontal impacts with reclined occupants. Under Review
- Richardson et al. 2020, IRCOBI: Pelvis kinematics and injuries of reclined occupants in frontal crashes. Planned Submission
- Richardson et al. 2020, STAPP: Kinematic and injury response of reclined PMHS in a vehicle-based test environment. Planned Submission

These publications will provide detailed descriptions of the response of mid-sized male PMHS in the frontal crash environment, the injuries sustained by the occupants, kinematic and kinetic response corridors, and in-depth analysis

4040 Lewis & Clark Dr. | Charlottesville, VA 22911 USA | +1 434-297-8049 | jrk3z@virginia.edu

of all of the test results. These data will provide an excellent reference by which the biofidelity of HBMs can be evaluated, and a rich description of the risks to reclined vehicle occupants in frontal crashes.

As an attachment to this letter, we are including the average and standard deviation of the initial pre-test positions of individual body segments for the PMHS used in the experiments. If part of the OSCCAR project aims to evaluate the biofidelity of different HBMs, or simply to compare predictions between HBMs, we offer this positioning data as a reference position data set for positioning HBMs.

We hope you will share the data, and its associated description, with the members of the OSCCAR project, and that you consider using it in the specific tasks of the project. If you do choose to use the data, we request now that you make reference to the 2019 ESV Conference study (Richardson et al. 2019) for now. However, as these other papers are published in the open literature, please reference the study that contains the specific data used in your work.

Please do not hesitate to contact us if you have any questions about the data and how to use it with HBMs.

Respectfully,

Jason R. Kerrigan PhD

Rachel E. Richardson

Reference:

Richardson R, Donlon JP, Chastain K, Shaw G, Forman J, Sochor S, Jayathirtha M, Kopp K, Overby B, Gepner B, Kerrigan JR, Ostling M, Mroz K, Pipkorn B. (2019) Test methodology for evaluating the reclined seating environment with human surrogates. Proceedings of the 26th International Technical Conference on the Enhanced Safety of Vehicles (ESV). Paper Number 19-0243. June 2019. https://www-esv.nhtsa.dot.gov/Proceedings/26/26ESV-000243.pdf

4040 Lewis & Clark Dr. | Charlottesville, VA 22911 USA | +1 434-297-8049 | jrk3z@virginia.edu

PMHS Positioning Data

- Average from PMHS tests S0529, S0531, S0532 and S0533
- Reclined postures
- All positioning data in the global coordinate system of the SAFER HBM system model

PMHS Anthropometry

Test #	Subject ID	Gender	Age	Weight (kg)	Stature (cm)
S0529	930	Male	66	74.4	175
S0531	901	Male	72	73.9	185
S0532	662	Male	25	75.0	174
S0533	815	Male	55	74.4	180

- All PMHS close to 50th perc male Age 25-72yo

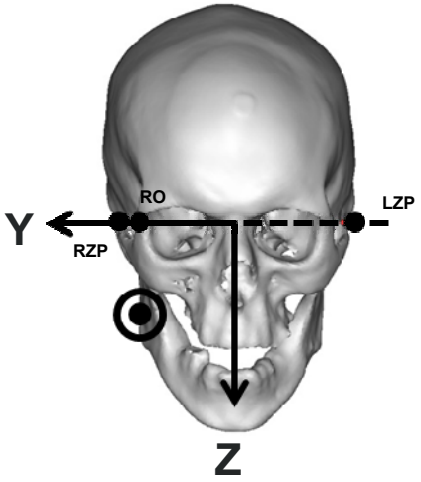
Positioning Data

Measurement Point	Definition	ID	X (mm)	Y (mm)	Z (mm)	SD X (mm)	SD Y (mm)	SD Z (mm)
Origin of Coordinate System	Seat edge right side	1	3196,7	-	461,7	-	-	-
Head Top	-	1500	3472,0	-	1264,0	50,1	-	33,6
Head Origin Position	Midpoint btw L/R zygomatic processes	2500	3512,5	-	1137,6	26,7	-	32,1
Head Angle (deg)	Midpoint btw L/R zygomatic process to midpoint btw eye orbits		33,6			2,6		
T1 Origin Position	Center of vertebral body	5500	3467,3	-	996,3	23,1	-	15,1
T8 Origin Position	Center of vertebral body	6500	3421,4	-	844,3	8,0	-	12,2
T11 Origin Position	Center of vertebral body	7500	3374,2	-	787,5	4,4	-	15,9
L1 Origin Position	Center of vertebral body	8500	3320,9	-	744,1	3,1	-	22,6
L3 Origin Position	Center of vertebral body	9500	3255,0	-	701,7	14,0	-	5,9
Pelvis Origin Position*	Midpoint btw L/R PSIS	10500	3191,4	-	577,0	6,6	-	12,5
Pelvis Angle (deg)*	Angle of the vector from pubic symphysis to midpoint btw L/R ASIS with respect to the vertical		74,3			8,7		
Pelvis Angle (deg)*	Angle of the vector from midpoint btw L/R PSIS to midpoint btw L/R ASIS with respect to the horizontal		63,3			4,0		
Right Knee Position	Center lateral epicondyle	17500	2658,7	-	750,9	19,9	-	28,2
Left Knee Position	Center lateral epicondyle	18500	2660,2	-	754,1	7,0	-	28,6
Right Heel Position	-	19500	2419,7	-	350,9	1,9	-	7,5
Left Heel Position	-	20500	2418,8	-	351,2	5,4	-	12,5
Sternum	Midpoint btw L/R 4th rib insertion points	23500	3299,3	-	928,8	20,8	-	15,5
HP Center btw R and L*	Midpoint btw L/R hip points	26500	3077,4	-	643,3	1,0	-	3,4

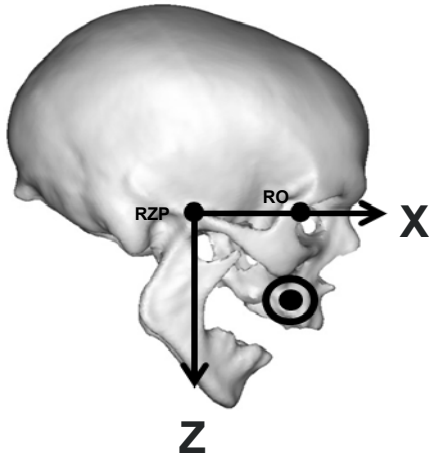
*Data from S0531 not included in pelvis measurements

Coordinate System Definitions: Head

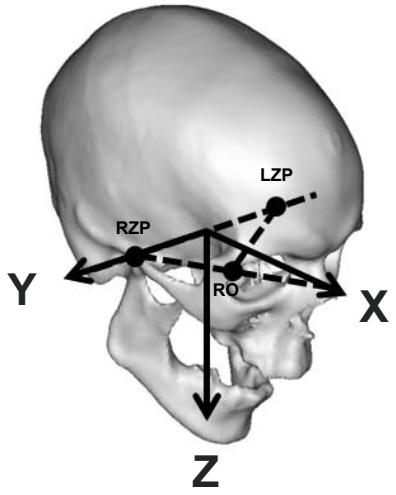
- Anterior Aspect



- Lateral Aspect



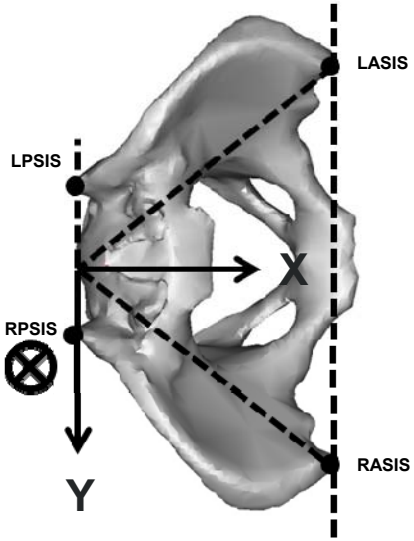
- Isometric Aspect



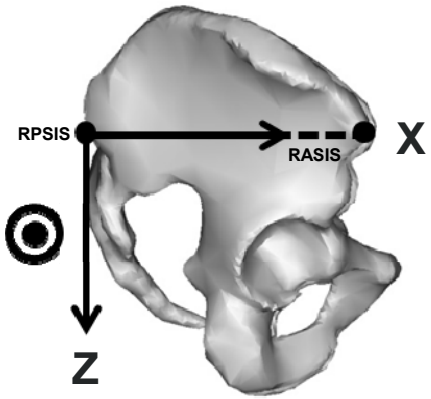
Landmark Abbreviation	**Landmark Definition**
RZP	Right Zygomatic Process
LZP	Left Zygomatic Process
RO	Right Orbit
Coordinate	**Coordinate Definition**
Origin	Midpoint of RZP and LZP
X-axis	Perpendicular to the Y-axis, and lying in the plane containing RZP, LZP, and RO, positive anteriorly
Y-axis	Passing through RZP and LZP, positive to the right
Z-axis	Perpendicular to the X- and Y-axes, positive inferiorly

Coordinate System Definitions: Pelvis

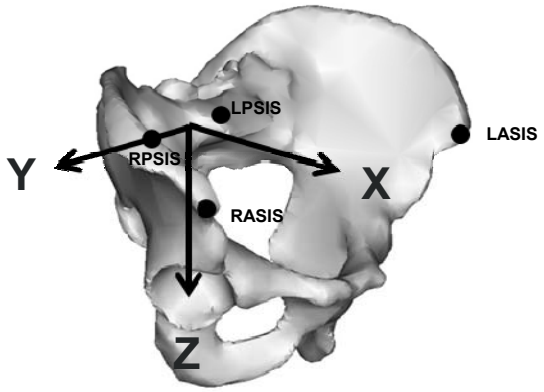
- Anterior Aspect



- Lateral Aspect



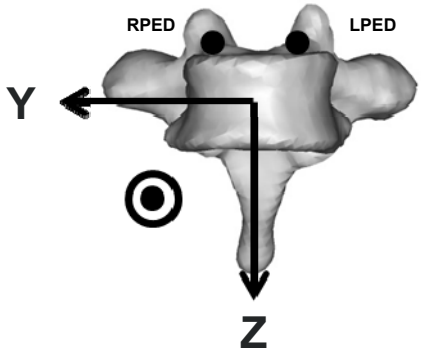
- Isometric Aspect

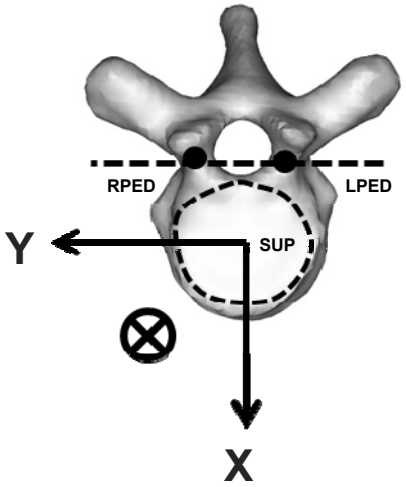


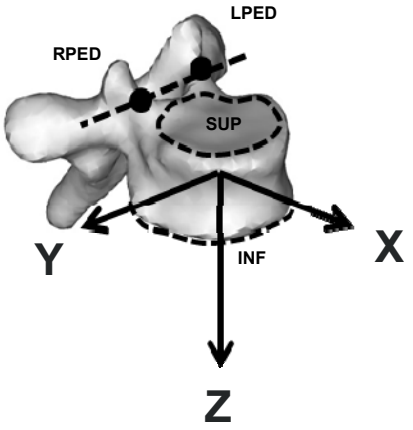
Landmark Abbreviation	**Landmark Definition**
RASIS	Right Anterior Superior Iliac Spine
LASIS	Left Anterior Superior Iliac Spine
RPSIS	Right Posterior Superior Iliac Spine
LPSIS	Left Posterior Superior Iliac Spine
Coordinate	**Coordinate Definition**
Origin	Midpoint of RPSIS and LPSIS
X-axis	Perpendicular to the Y- and Z-axes, positive anteriorly
Y-axis	Passing through RPSIS and LPSIS, positive to the right
Z-axis	Perpendicular to the line passing through the origin and RASIS and the line passing through the origin and LASIS, positive inferiorly

Coordinate System Definitions: Vertebra

- Anterior Aspect
- Lateral Aspect
- Isometric Aspect



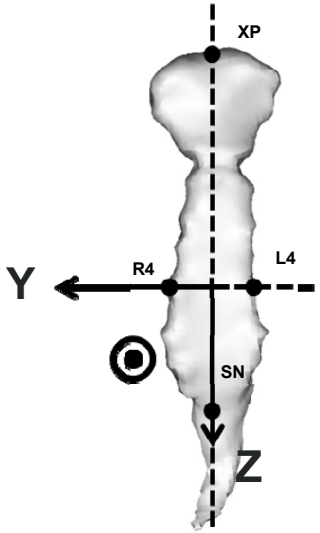




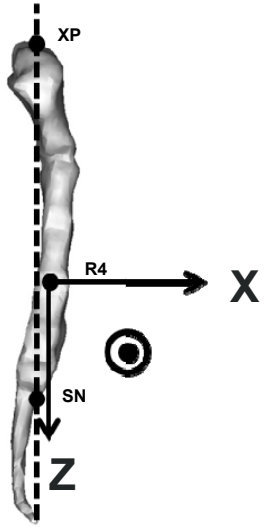
Landmark Abbreviation	Landmark Definition
RPED	Right Pedicle
LPED	Left Pedicle
SUP	Center of Superior Endplate
INF	Center of Inferior Endplate
Coordinate	**Coordinate Definition**
Origin	Midpoint of SUP and INF
X-axis	Perpendicular to both the Z-axis and the line passing through RPED and LPED, positive anteriorly
Y-axis	Perpendicular to the X- and Z-axes, positive to the right
Z-axis	Passing through SUP and INF, positive inferiorly

Coordinate System Definitions: Sternum

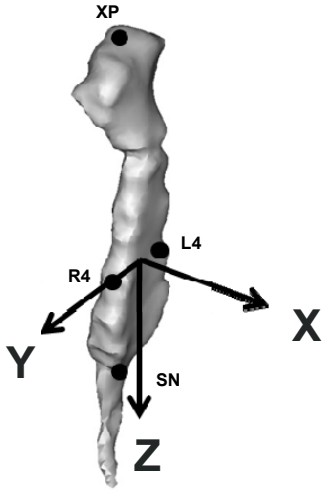
- Anterior Aspect



- Lateral Aspect



- Isometric Aspect



Landmark Abbreviation	**Landmark Definition**
R4	Center of Right 4th Rib Insertion Point
L4	Center of Left 4th Rib Insertion Point
SN	Suprasternal Notch
XP	Xiphoid Process
Coordinate	**Coordinate Definition**
Origin	Midpoint of R4 and L4
X-axis	Perpendicular to the Z-axis and the line passing through R4 and L4, positive anteriorly
Y-axis	Perpendicular to the X- and Z-axes, positive to the right
Z-axis	Parallel to the line passing through SN and XP, positive inferiorly

Coordinate System Definitions: Knee and Heels

- Origin marked as surface points measured at:
  - Knee: center of lateral epicondyle (right and left)
  - Heel: most posterior surface of calcaneus