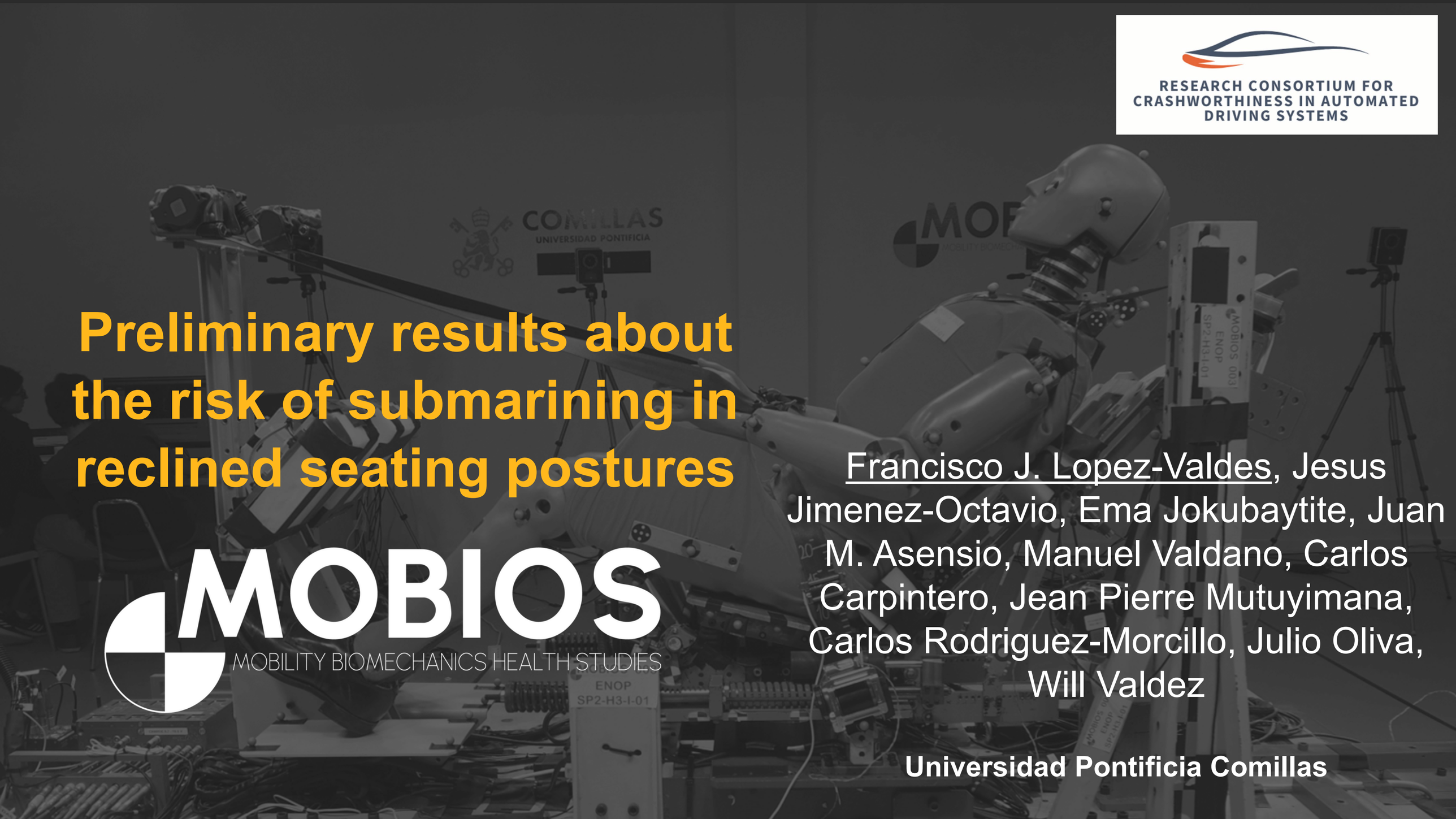


RESEARCH CONSORTIUM FOR CRASHWORTHINESS IN AUTOMATED DRIVING SYSTEMS

Preliminary results about the risk of submarining in reclined seating postures

MOBIOS
MOBILITY BIOMECHANICS HEALTH STUDIES

Francisco J. Lopez-Valdes, Jesus Jimenez-Octavio, Ema Jokubaytite, Juan M. Asensio, Manuel Valdano, Carlos Carpintero, Jean Pierre Mutuyimana, Carlos Rodriguez-Morcillo, Julio Oliva, Will Valdez

Universidad Pontificia Comillas

ENOP Enable New Occupant Seating Positions

UVA School of Engineering & Applied Science
Center for Applied Biomechanics

Medical College of Wisconsin

UMTRI Transportation Research Institute University of Michigan

LAB Accidentologie, Biomécanique, Comportement Humain

TOYOTA

Autoliv

ceesar

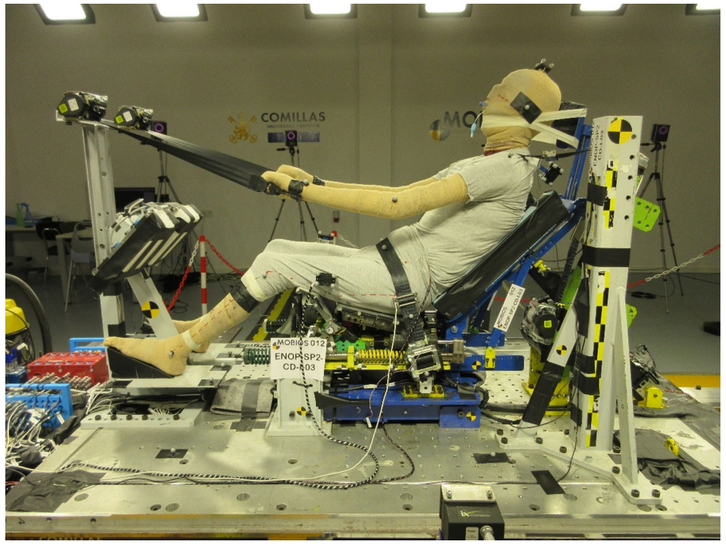
FORVIA faurecia

COMILLAS Universidad Pontificia ICAI

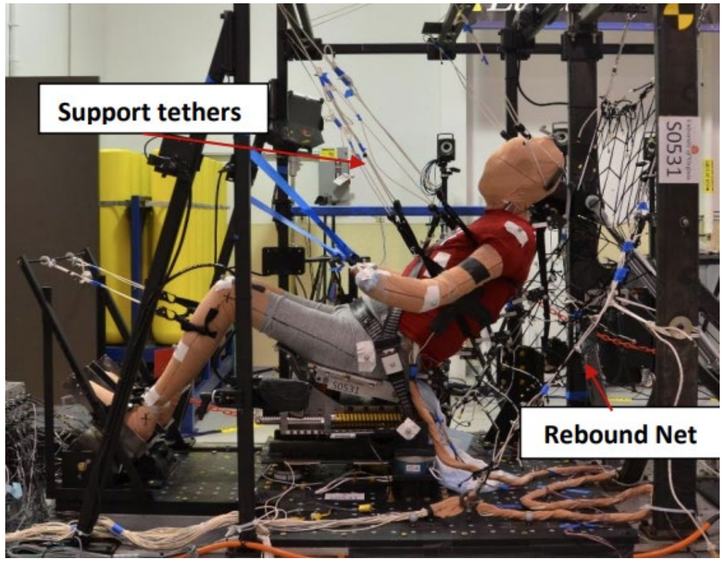
bast Bundesanstalt für Straßenwesen

CELLBOND ATD

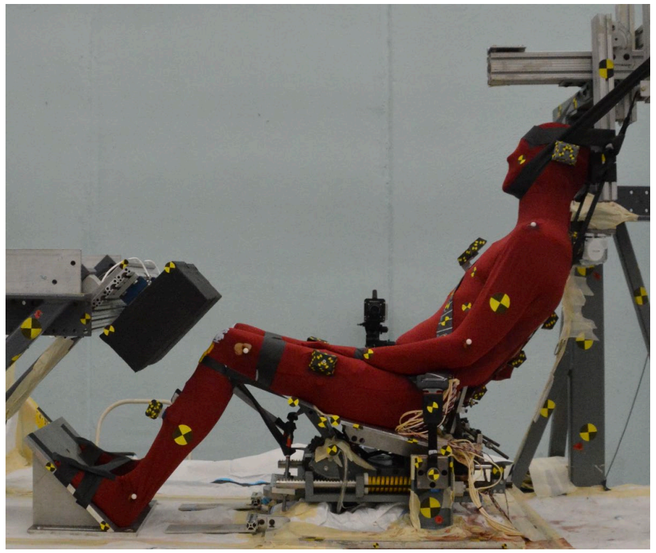
Université Gustave Eiffel



Ostling et al, 2023
Lopez-Valdes et al, 2023, 2024



Richardson et al, 2019, 2020
Shin et al, 2023



MOBIOS Mobility Biomechanics Health Studies

Cervical spine	C6, C7	C7	C2, C5-C6, C7
Thoracic spine	T1, T2, T12 Vertebral body, transverse processes fx	T1, T2, T12	T2, T3, T7. T8, T9, T12 Endplate, vertebral body, transverse proceses fx
Lumbar spine	L1, L2 vertebral body fx	L1, L2	L1, L2, L3, L4, L5 Vertebral body, transverse processes fx
Sacrum	Fx	Fx	Fx
Pelvis	Iliac wing, pubic rami, ischial tuberosities	Iliac wing, pubic rami, pubic symphysis	Iliac wing, ischial tuberosities, pubic ramus, pubic symphysis
Ribs	>15 ribs fx	Multiple rib fx (average: 12 fx)	Multiple rib fx
Sternum	Body, manubrium fx		Manubrium, body fx

Reclined positions

- Severe injury pattern including:
  - Multiple rib and sternal fx
  - Pelvic fx
  - Spine fx
- Increased risk of submarining or submarining-like kinematics (associated to pelvic fx)
- Large forward displacement and sagittal rearward rotation of pelvis

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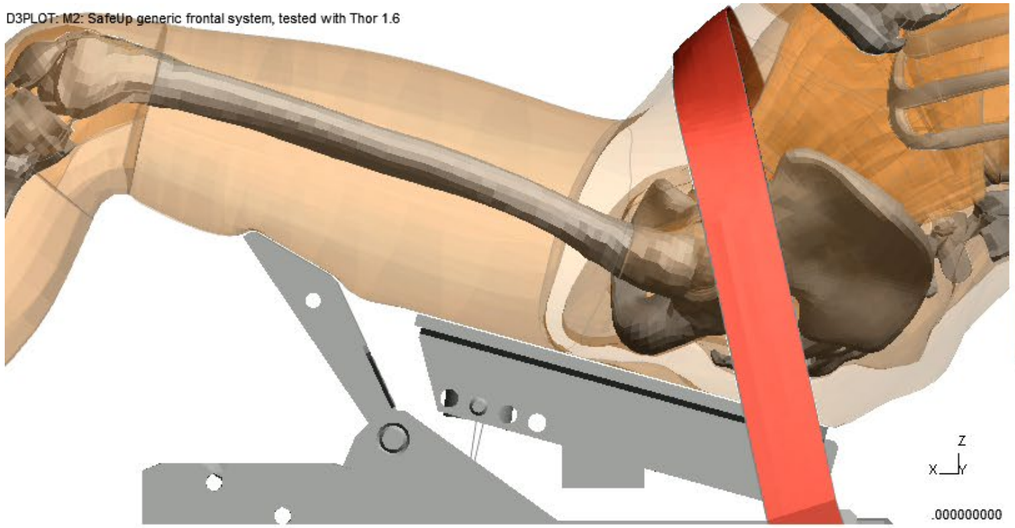
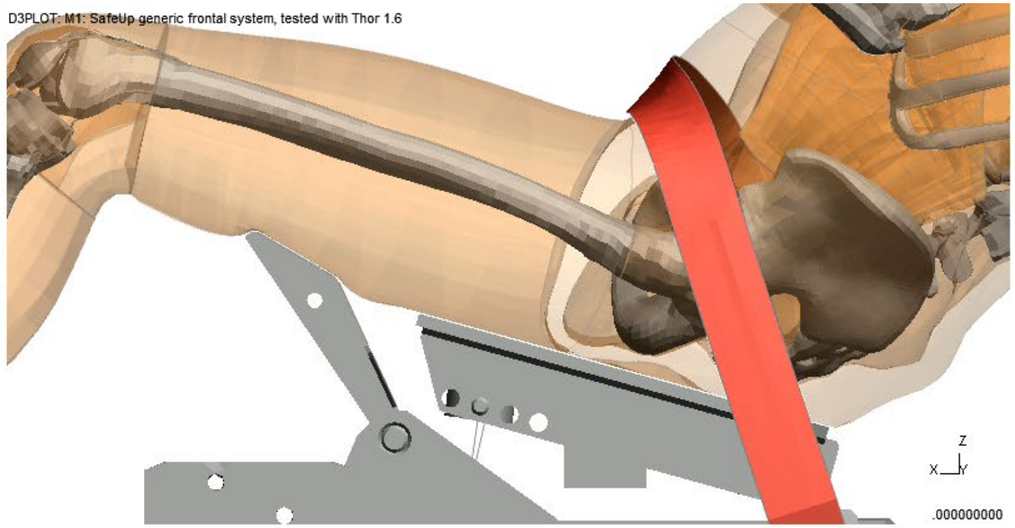
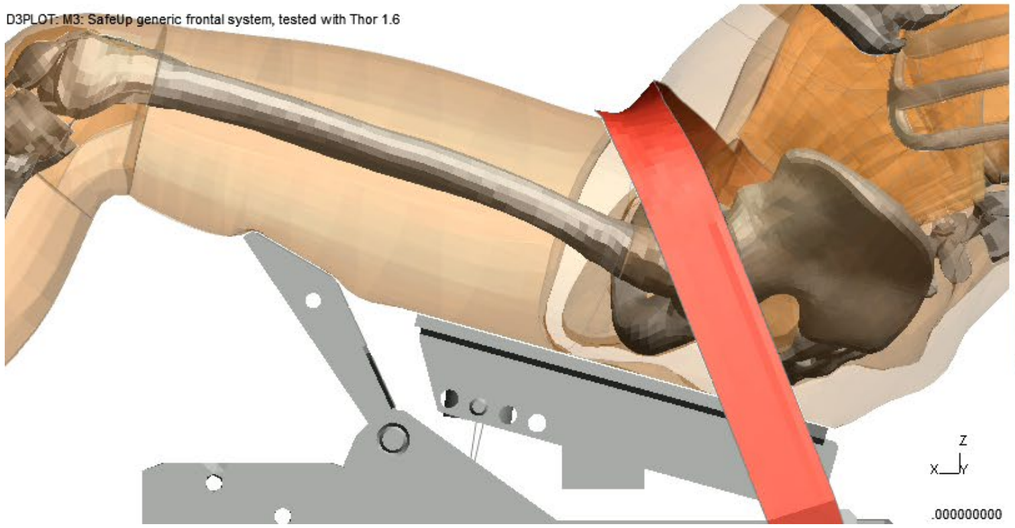
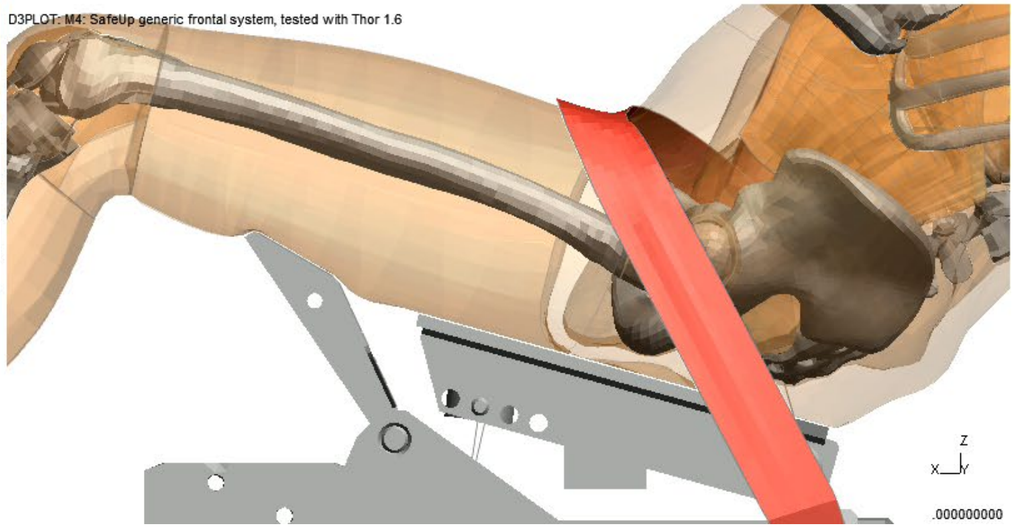
Sensitivity of HBM to lap belt initial position









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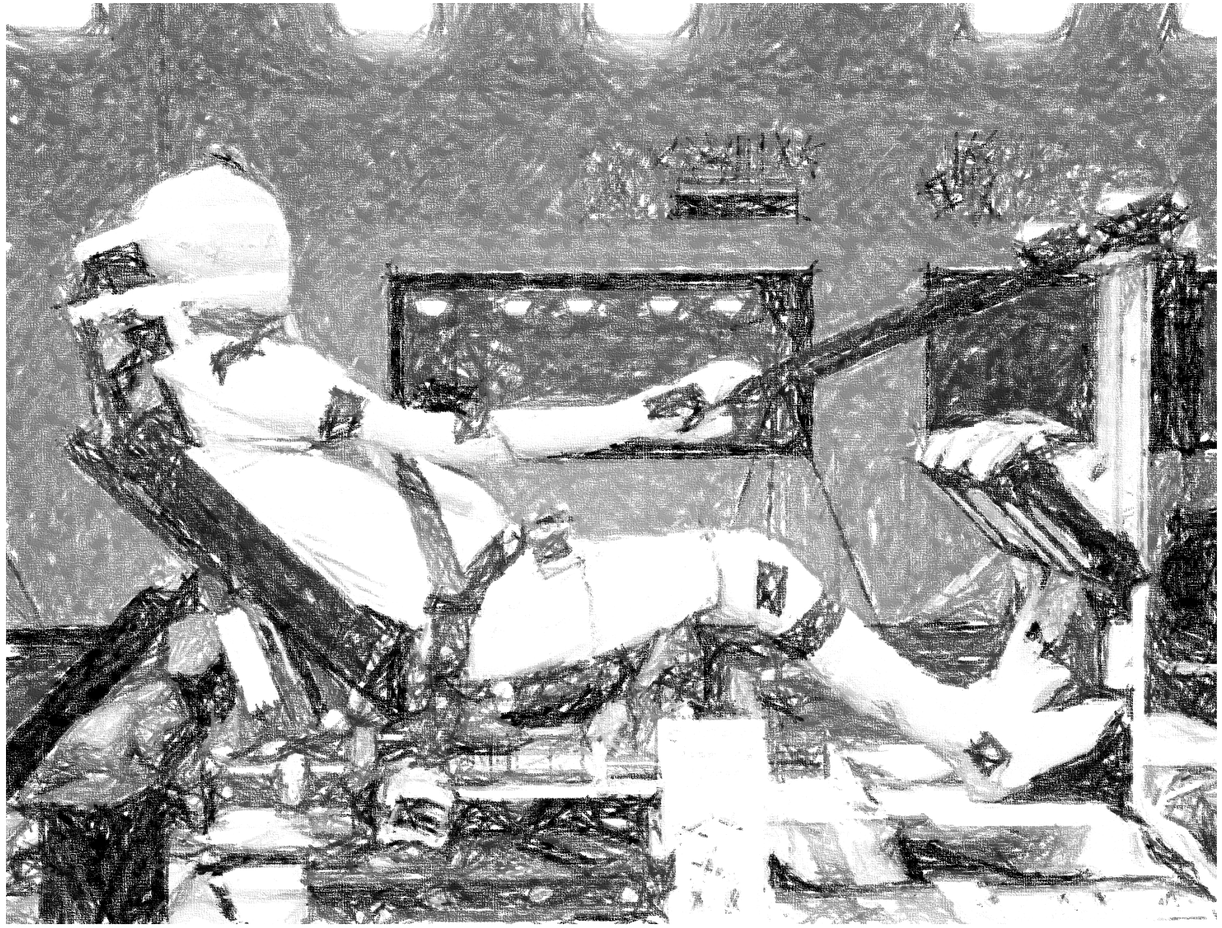
Objectives



- Performing repeated tests on the same PMHS: 2 low-speed, non-injurious; 1 high-speed, injurious.
- Document with precision the relative position of lap belt and pelvis, and test the same PMHS with two different positions of lab belt.
- Measure relative kinematics of pelvis and lap belt using 3D motion capture system.
- Document the injuries found in the high-speed tests.

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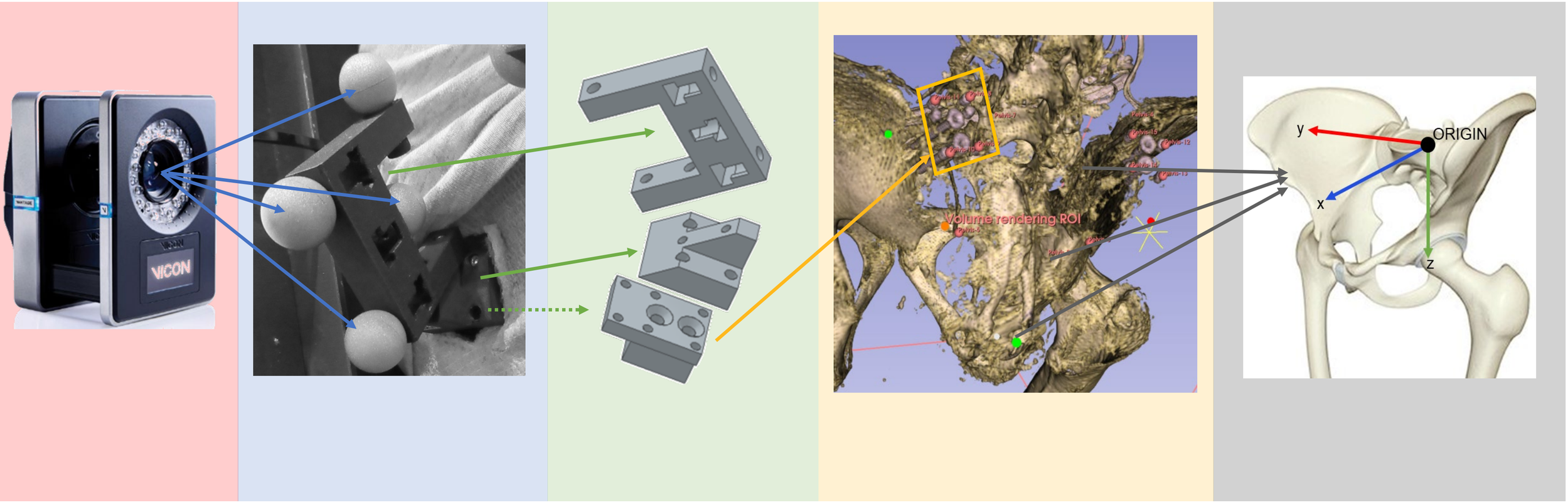
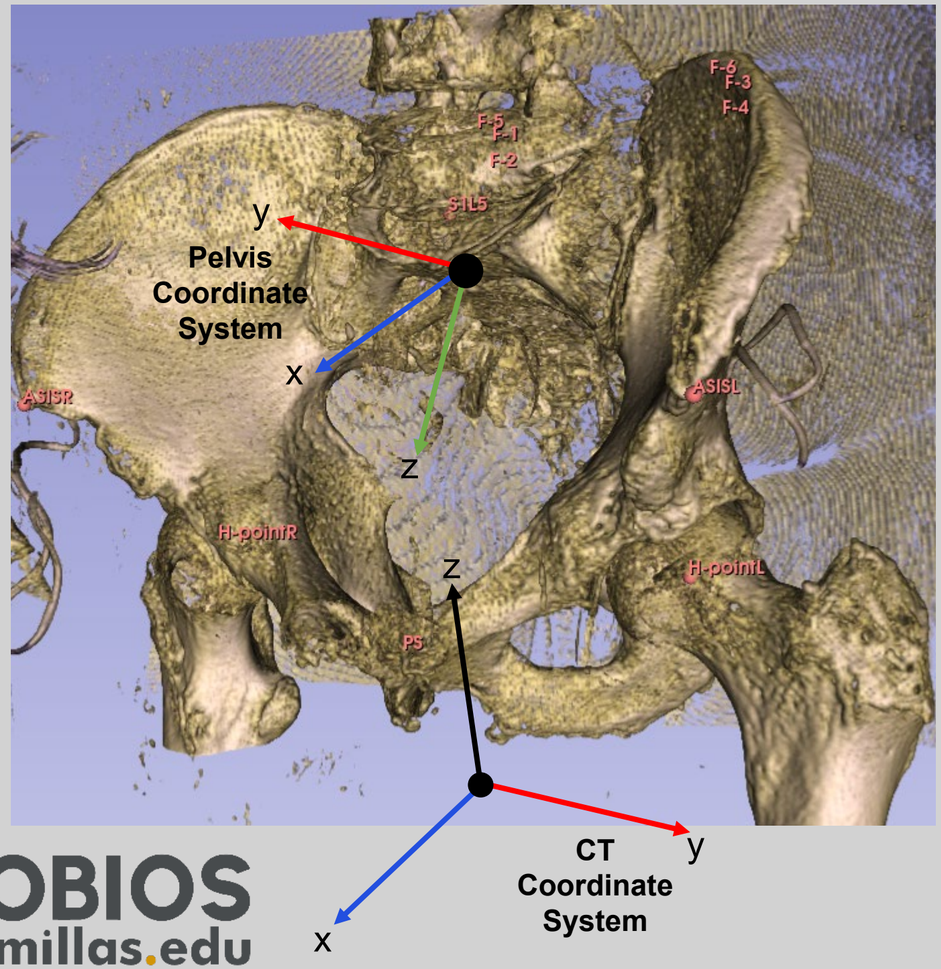
Methodology



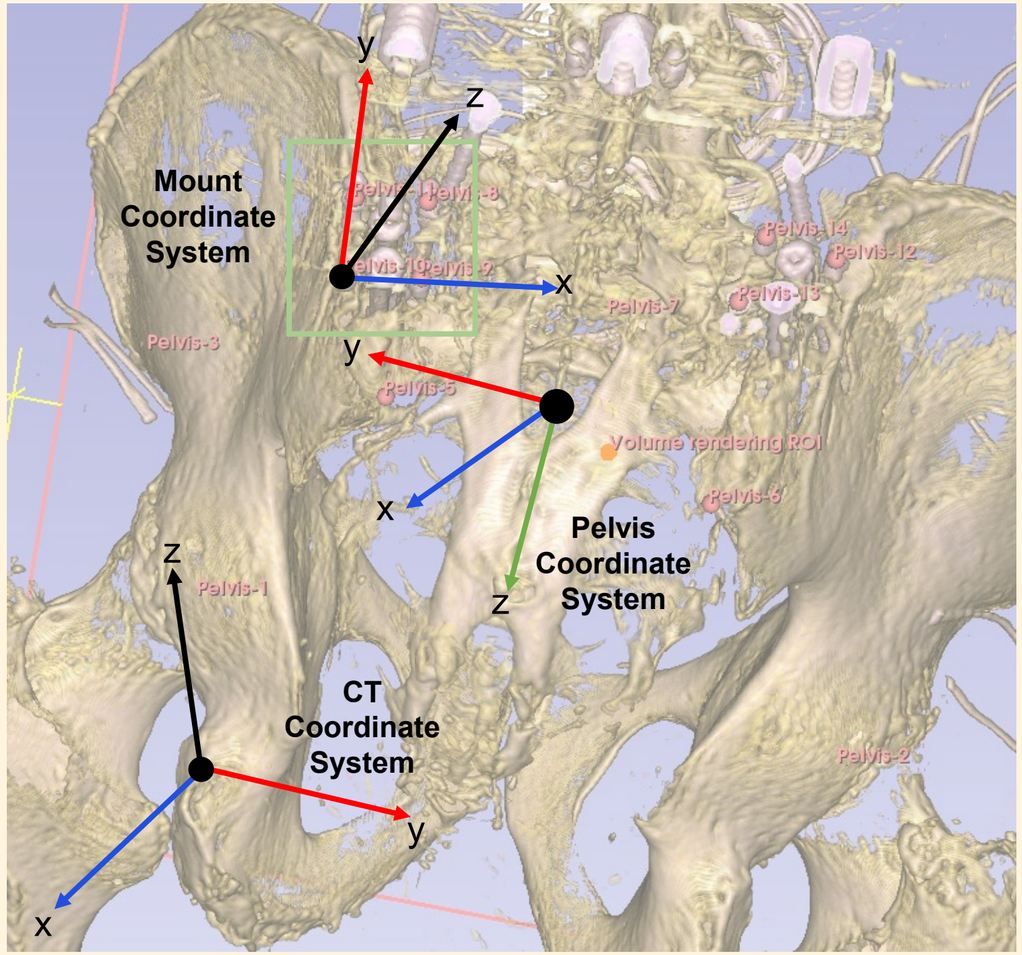
VICON cameras | VICON markers | Pelvic mount | CT scan | Pelvis

Methodology

1. Pelvis Local Coordinate System



2. CT scan



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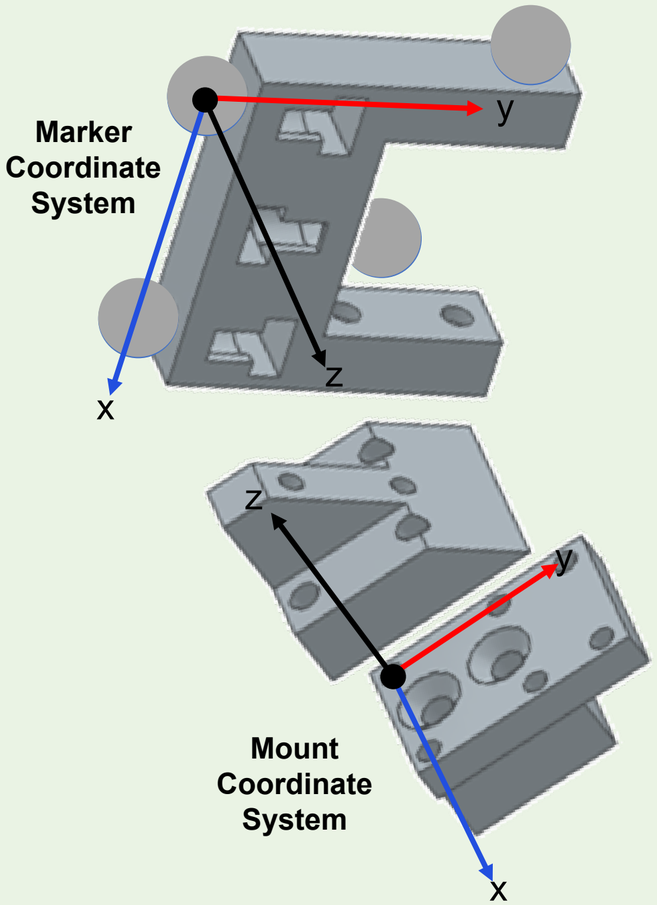
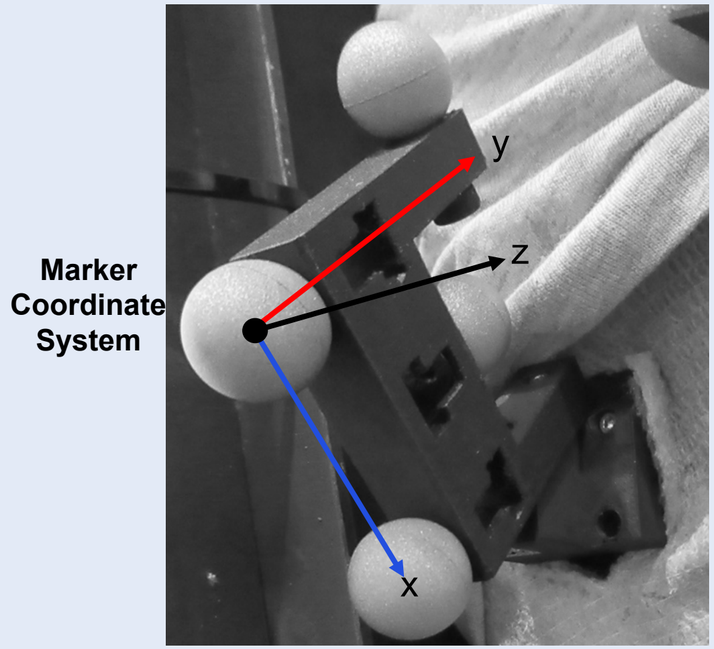
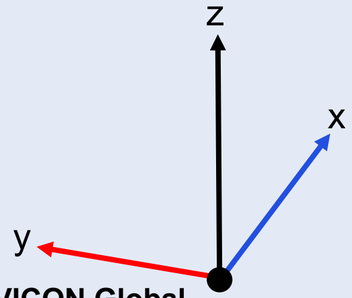
Methodology

2. Pelvic mount



3. VICON markers





VICON Global
Coordinate System

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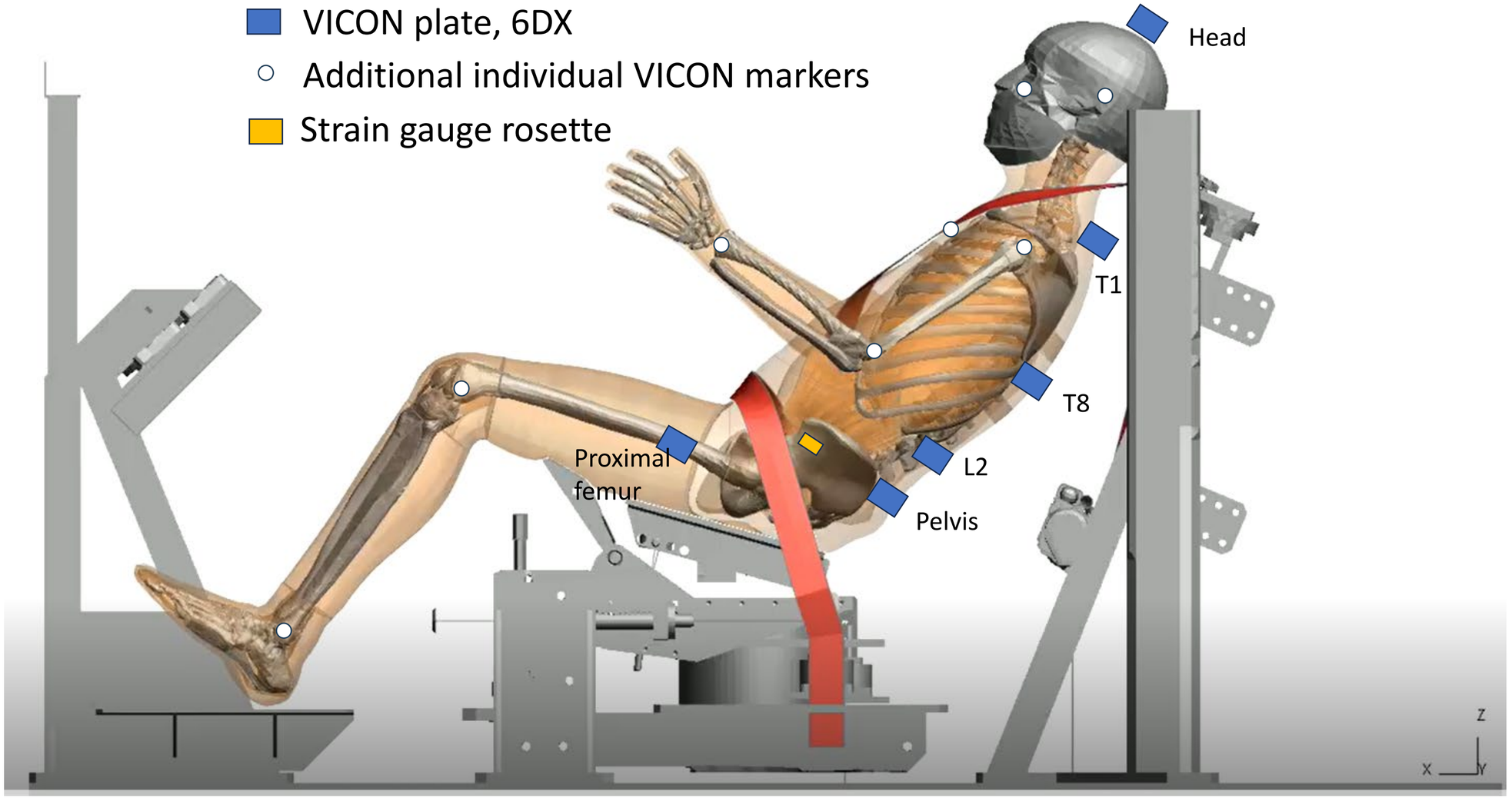
Instrumentation



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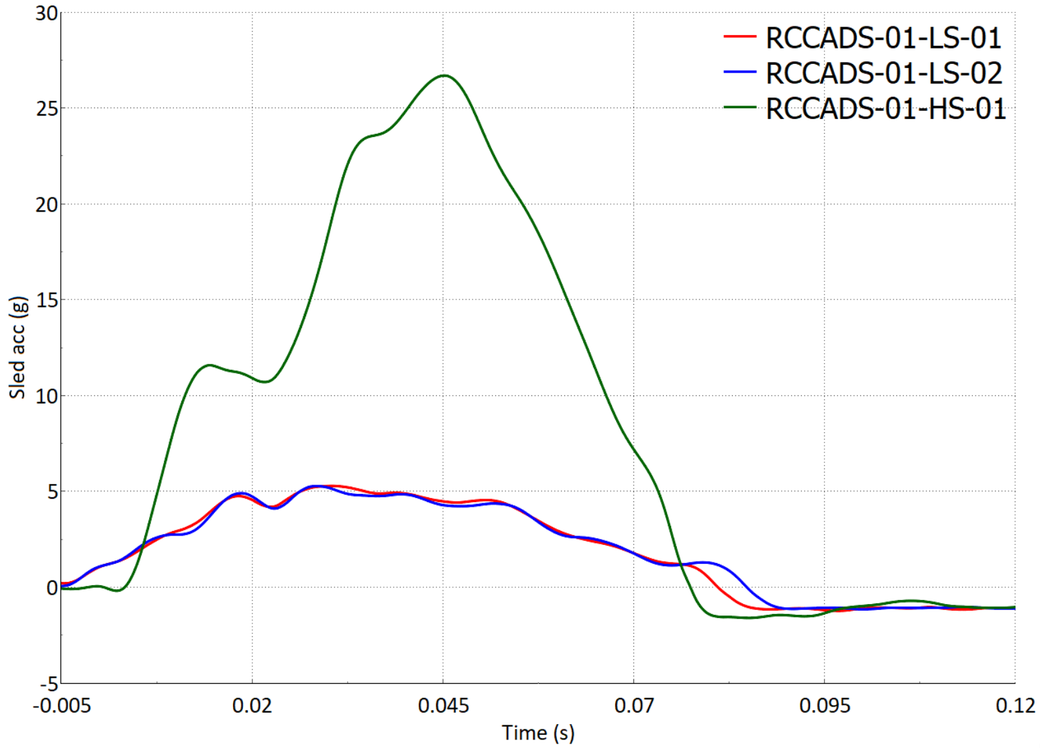
Test subjects and crash pulse

Donor ID	Age	Stature (cm)	Weight (kg)	Cause of death
0058F	86	162	58.4	Dementia
0063F	94	159	56.5	Bronchopneumonia

Test ID	Donor ID	Delta-v (km/h)	Position LB
RCCADS-01-LS-01	0058F	10*	High
RCCADS-01-LS-02	0058F	10*	Low
RCCADS-01-HS-01	0058F	40**	High



* Arbogast et al. 2008; Lopez-Valdes et al. 2010

** ENOP pulse

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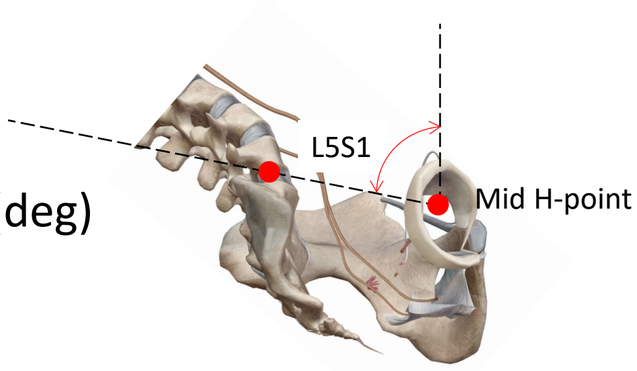
Comparison of initial position between runs

Landmarks	RCCADS-01-LS-01	RCCADS-01-LS-02	RCCADS-01-HS-01
H-point L (x, mm)	32.10	35.90	41.40
H-point R (x, mm)	36.00	42.40	43.80
Pelvic angle (deg)	77.90	78.50	81.00
PS (y, mm)	-3.70	-4.30	-3.50
ASIS L (x, mm)	5.3	7.70	11.40
ASIS R (x, mm)	4.3	10.70	7.90
Sternal notch (x, mm)	-125.79	-124.38	-130.65
Frankfort plane (deg)	26.1 / 24.0	34.0 / 34.0	33.1 / 30.1

Pelvic angle (deg)



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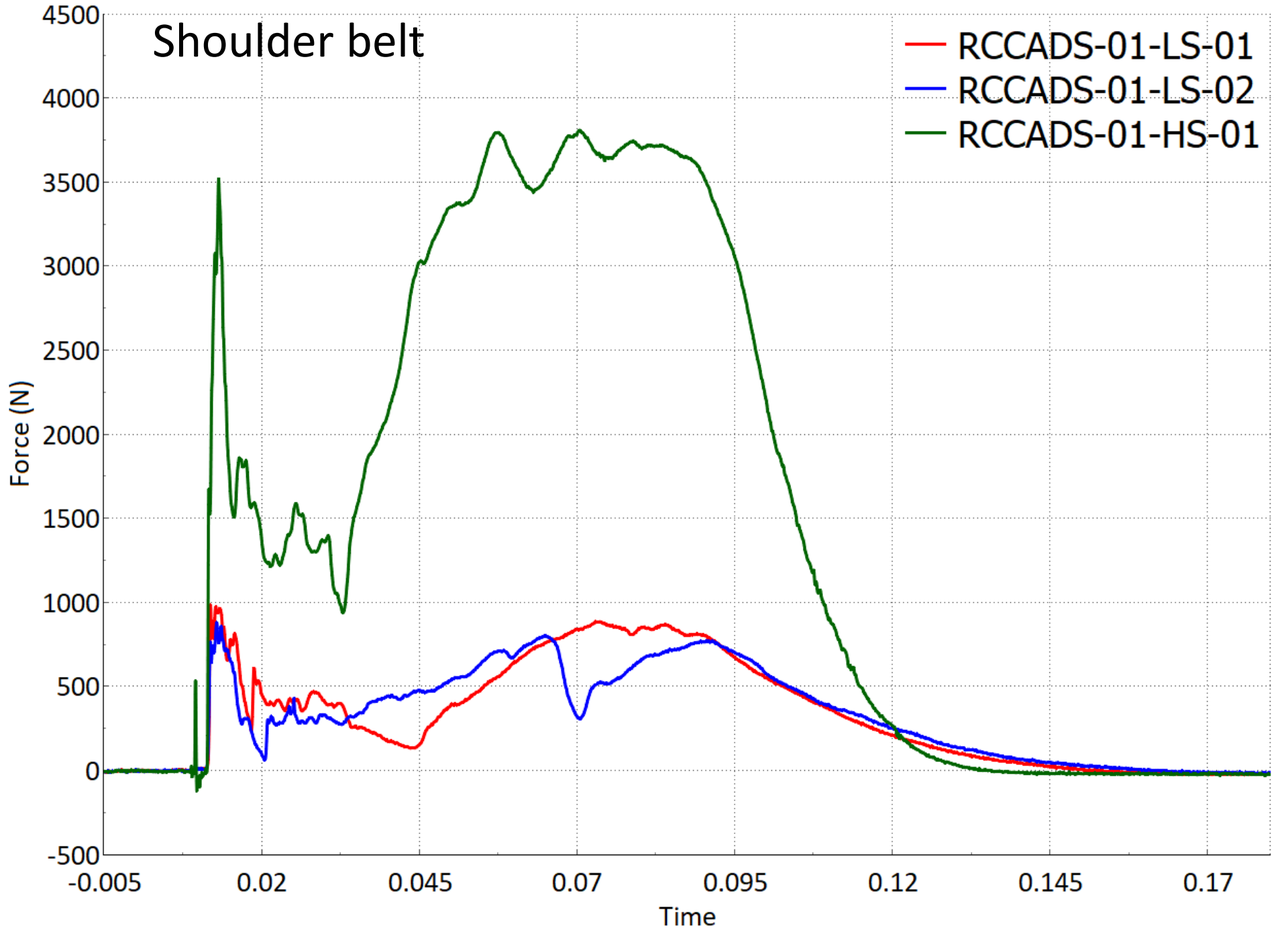
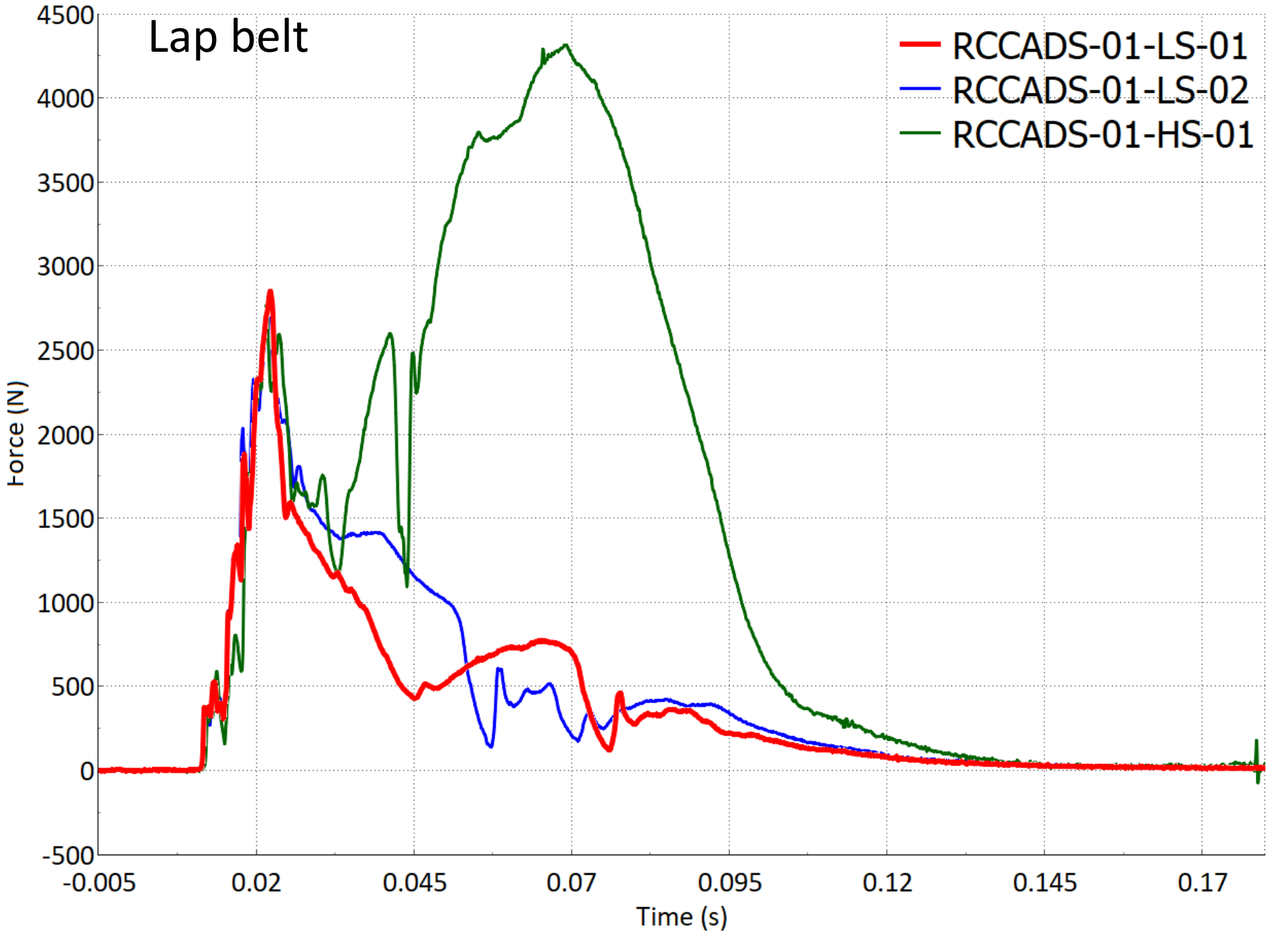
Seatbelt forces





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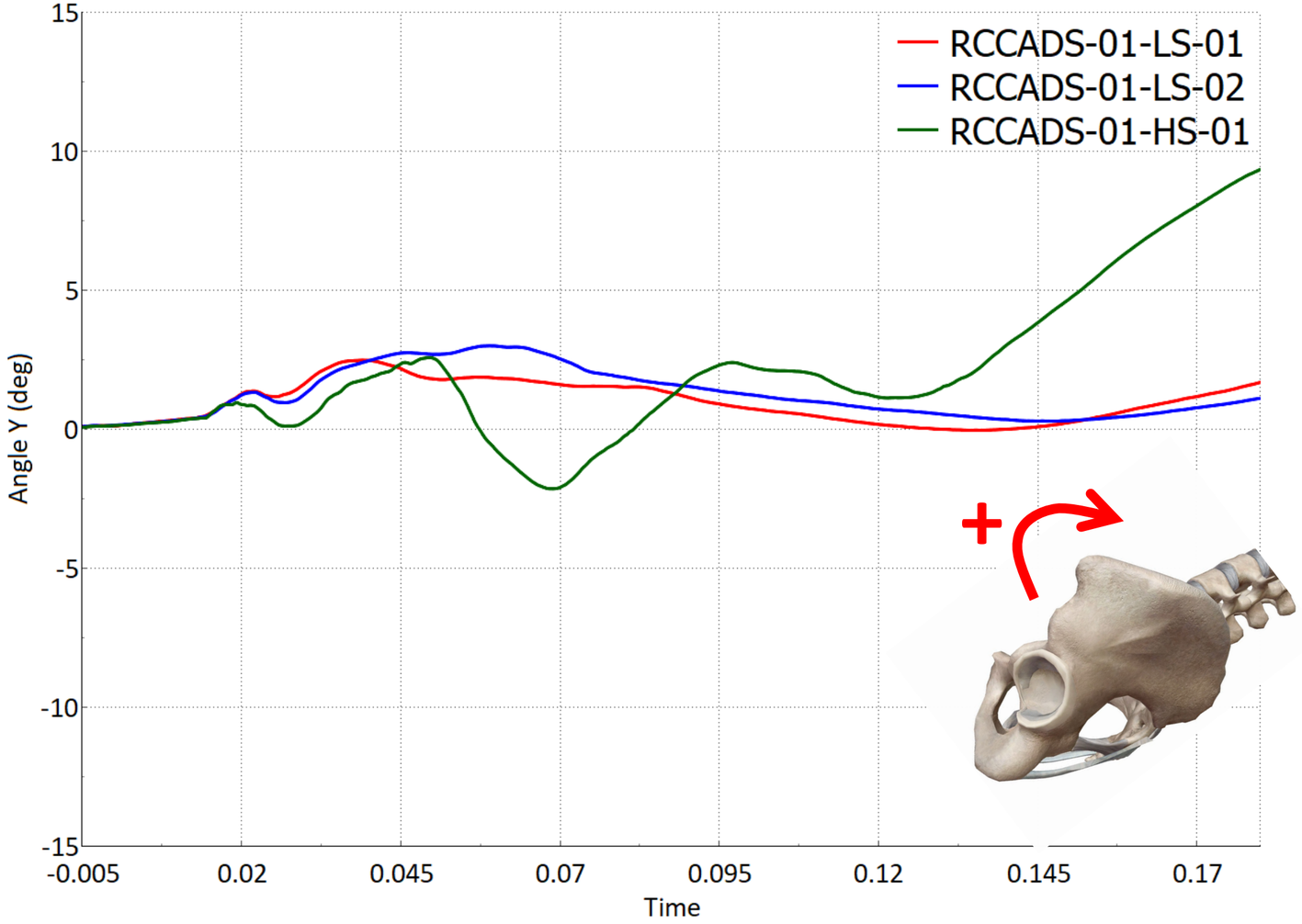
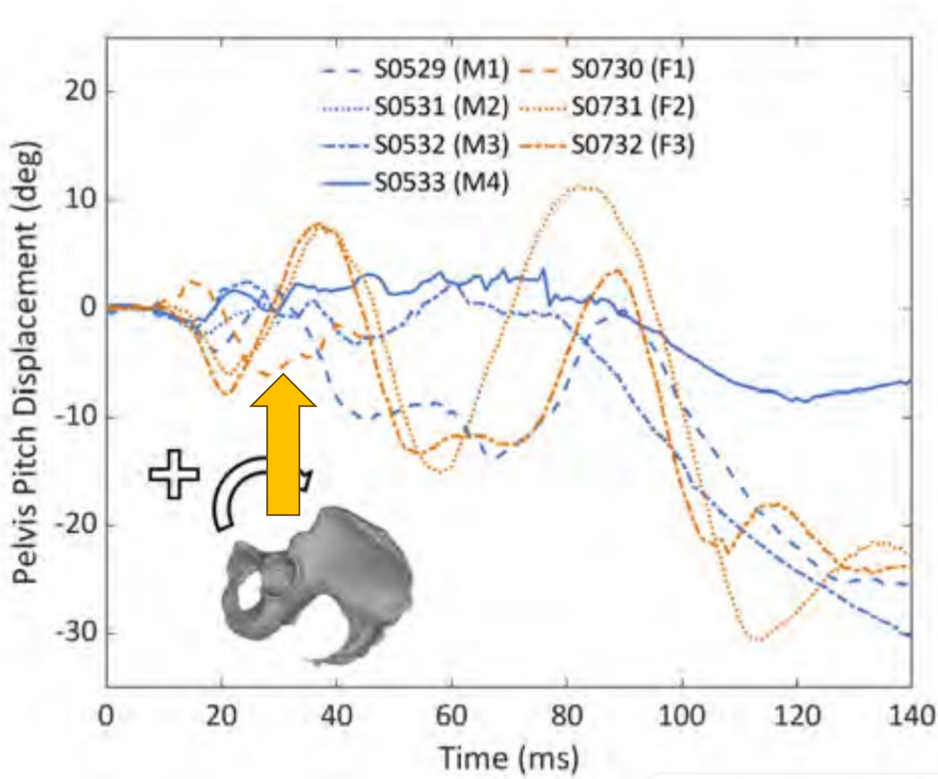
Calculated pelvic rotation in sagittal plane





Shin et al. 2023

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Acknowledgements

- The donors and their families, for their generous support of injury biomechanics research.
- RCCADS consortium for funding this study
- These tests are built upon knowledge gained during the testing performed for the ENOP Consortium.
- In particular, CEESAR and LAB allowed us to use the ENOP test fixture for these tests.
- The opinions expressed here do not necessarily represent the view of the RCCADS partners.

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