# The Relationship Between Pedestrian Component Legform and Full Dummy Testing in Assessing Bumper Performance

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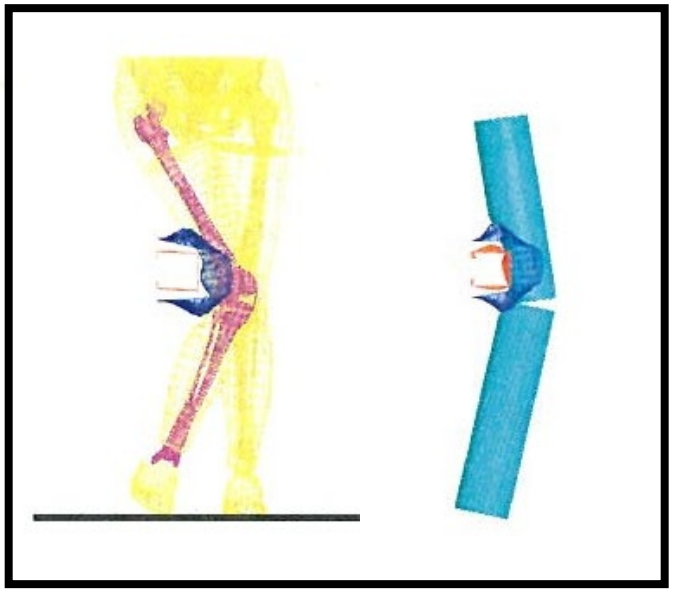
# Objective

How well do projectile tests represent pedestrian lower extremity impacts?


# Prior Studies

Cesari et al, ESV, 1991
Ishikawa et al, IRCOBI, 1992
Sakurai et al, ESV, 1991
Takahashi and Kikuchi, ESV, 2001
Matsui and Takabayashi,
JARI Research Journal, 2003

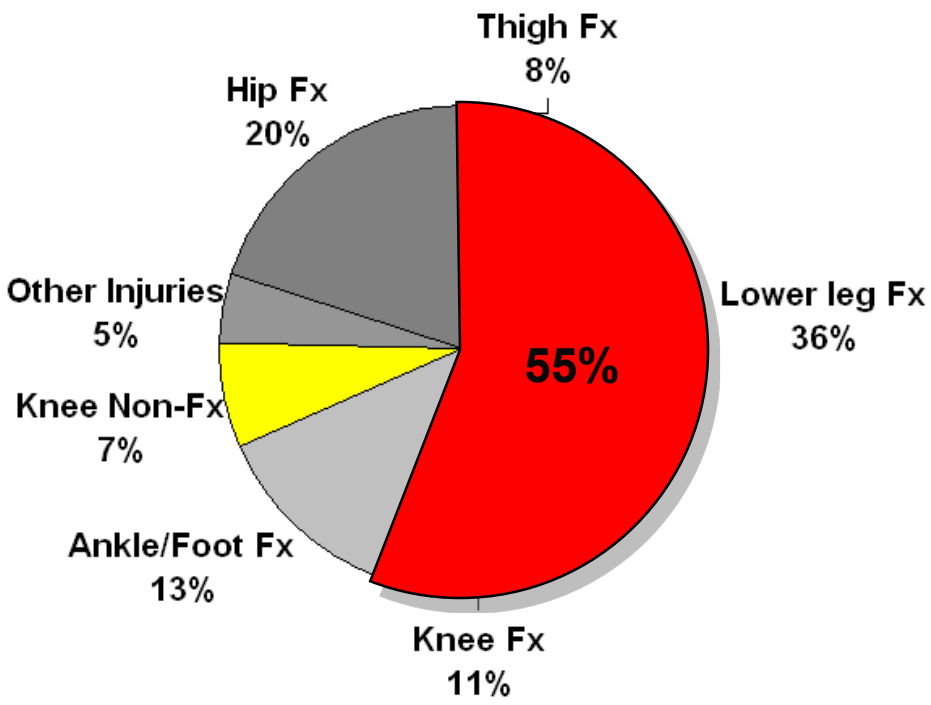


Focus on knee ligament injuries:

- Knee angle
- Knee moment
- Knee shear displacement

# Focus of Current Study

**PCDS**
**AIS 2+ Lower Extremity Injuries**
**1994-1998**

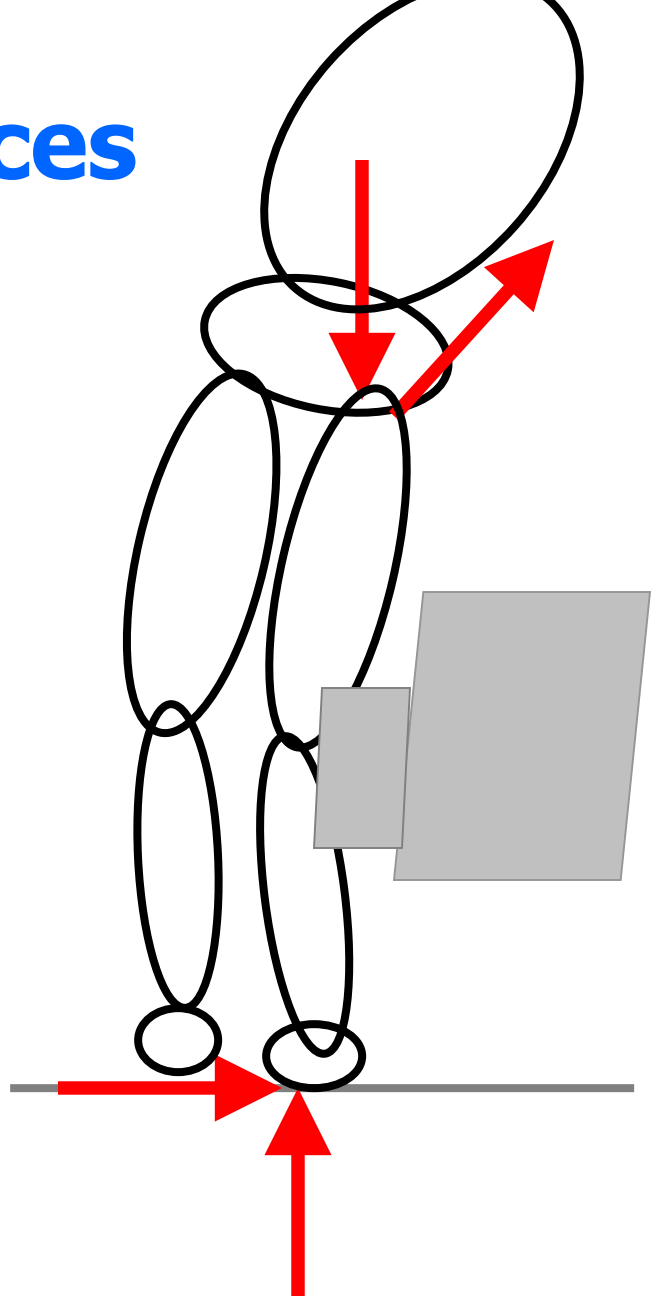



Focus on fracture measures:

- Femur moment
- Tibia moment
- Acceleration

# Key Physical Differences

| Pedestrian | Projectile |
|---|---|
| Initial axial load | No foot contact or body weight |
| Friction at foot | No foot contact |
| Upper body inertia | Thigh free to move |



# Key Physical Differences

| Pedestrian | Projectile |
|---|---|
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Polar II sled testing
48 km/h
1999 Honda Civic

*Stammen and Ko "Assessment of Polar II Pedestrian Dummy for Use in Full-Scale Case Reconstructions", NHTSA report DOT HS 809 391, 2001.*

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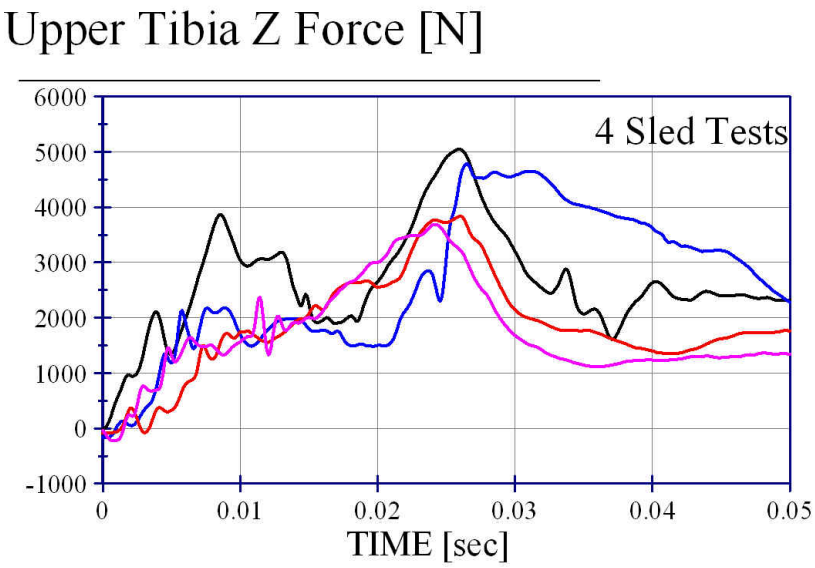


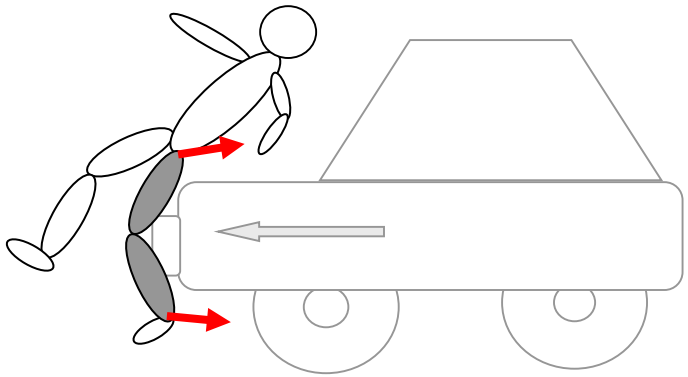

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|---|---|
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μ = 0.15

μ = 0.80

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|---|---|
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| Friction at foot | No foot contact |
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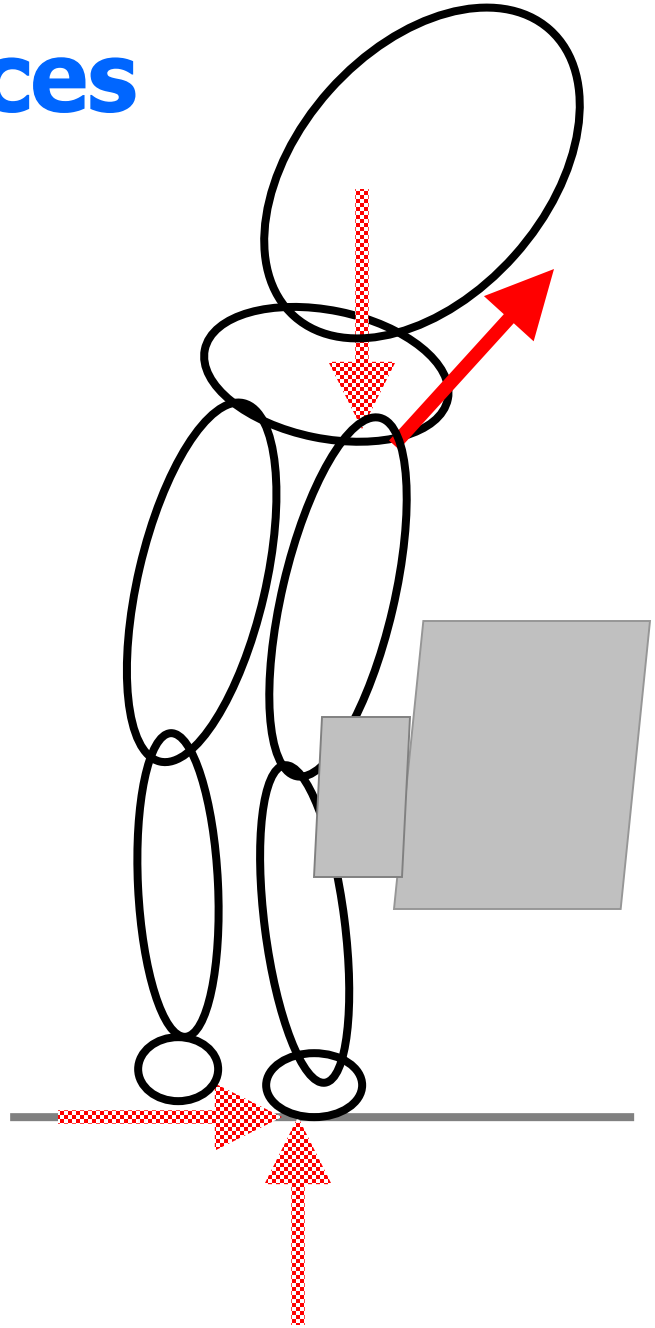
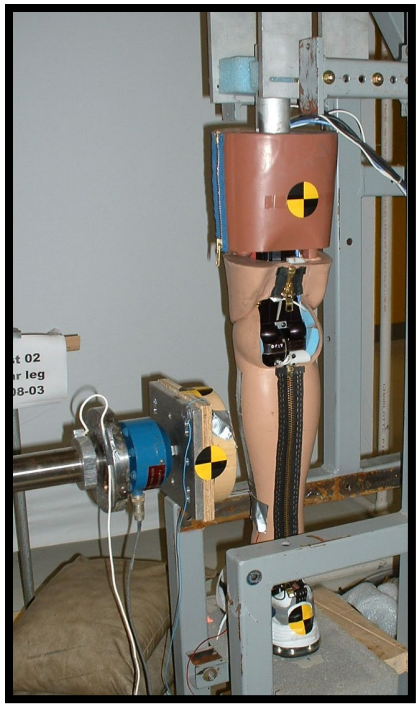
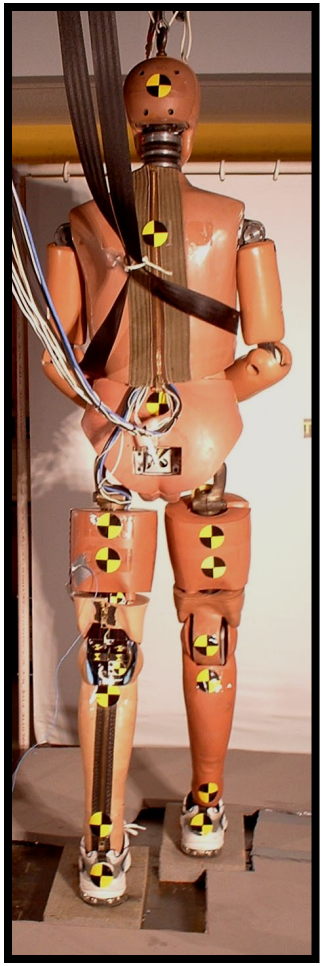


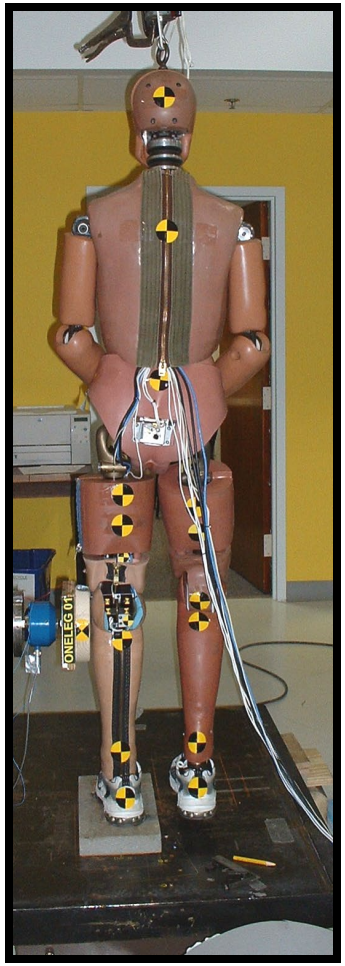
# Weight Conditions (3)



Leg only
(no weight)



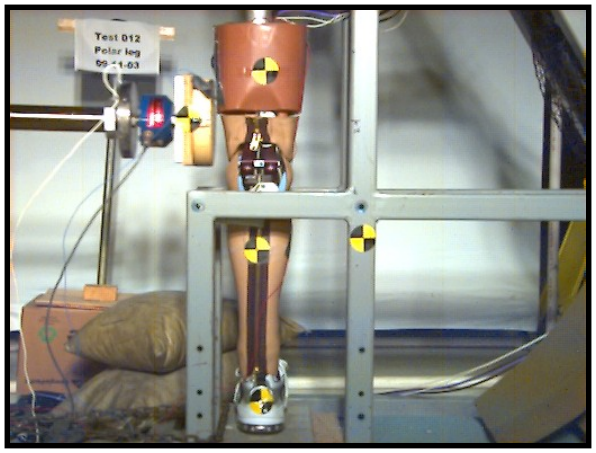
Two-leg stance
(mid weight)



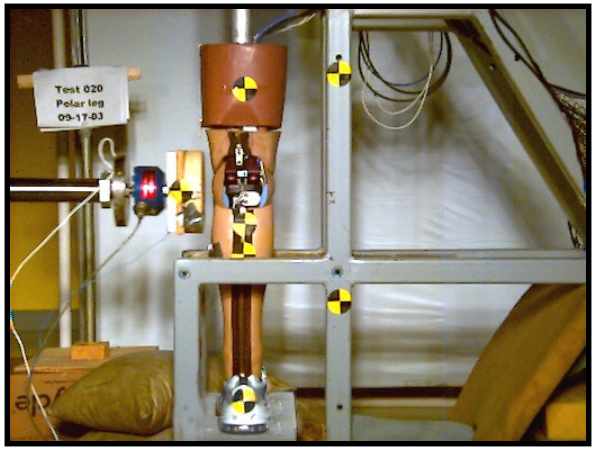
One-leg stance
(high weight)

# Impact Locations (3)

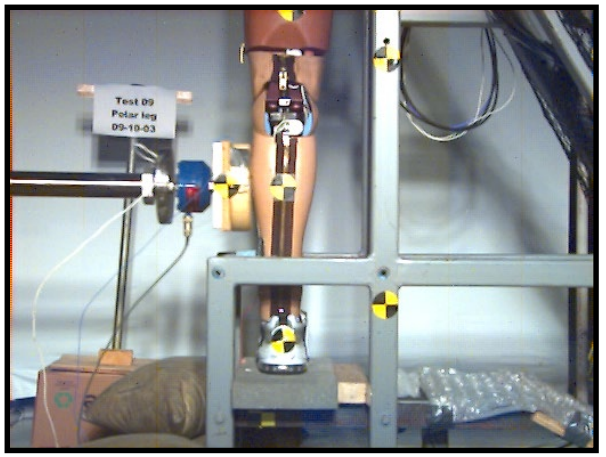
Femur impact



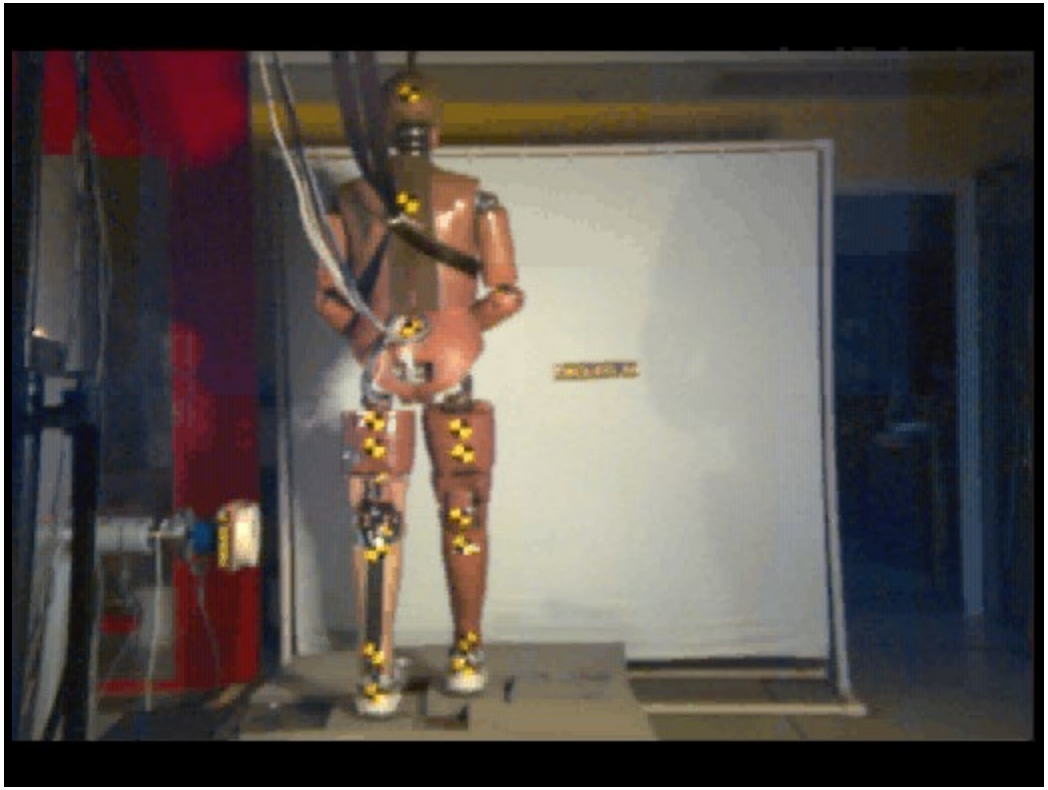

Knee impact




Tibia impact



## Polar II Legform with Hybrid III Body

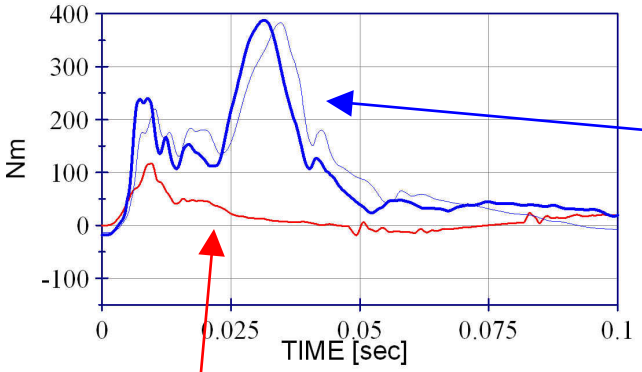


**Two-leg stance, Knee impact**

# *Inertial effects of upper body: Preliminary Results*

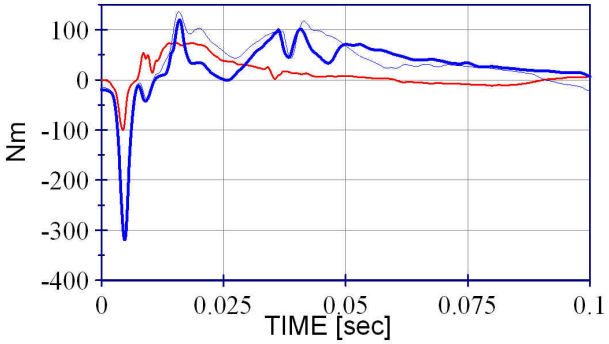
## Femur X Moment

Femur Level Impact:

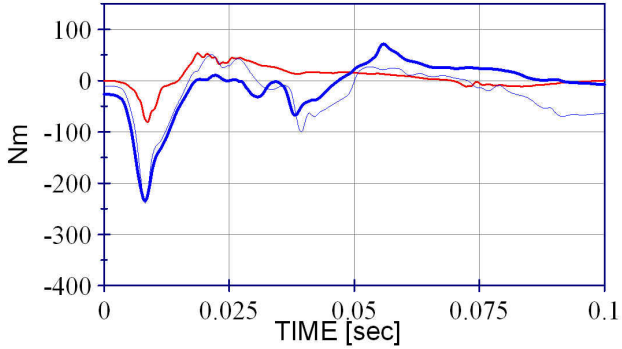



No Weight
Mid Weight
High Weight

Knee Level Impact:

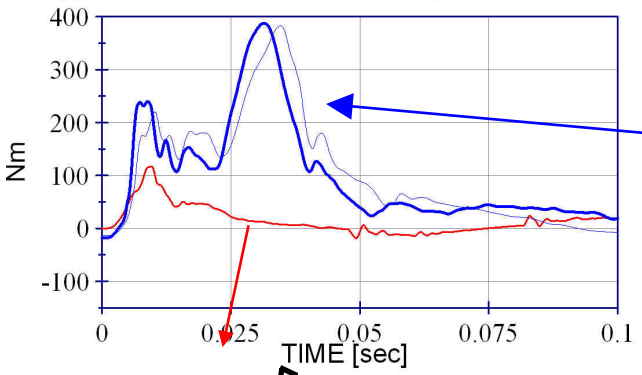


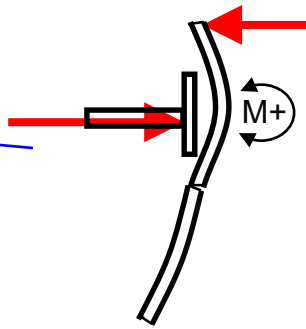

Tibia Level Impact:



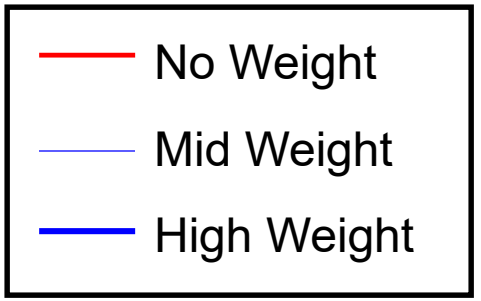
# *Inertial effects of upper body: Preliminary Results*

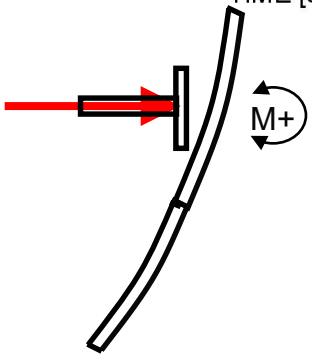
## Femur Level Impact:



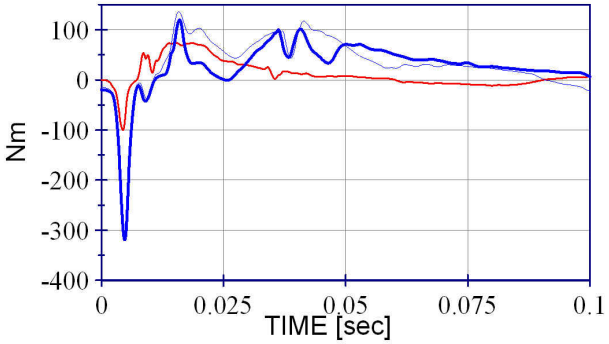




## Femur X Moment

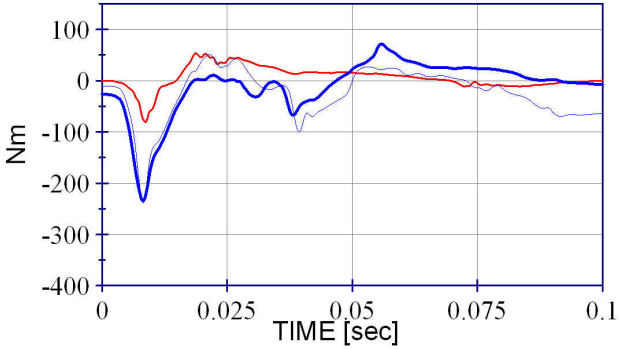



## Knee Level Impact:

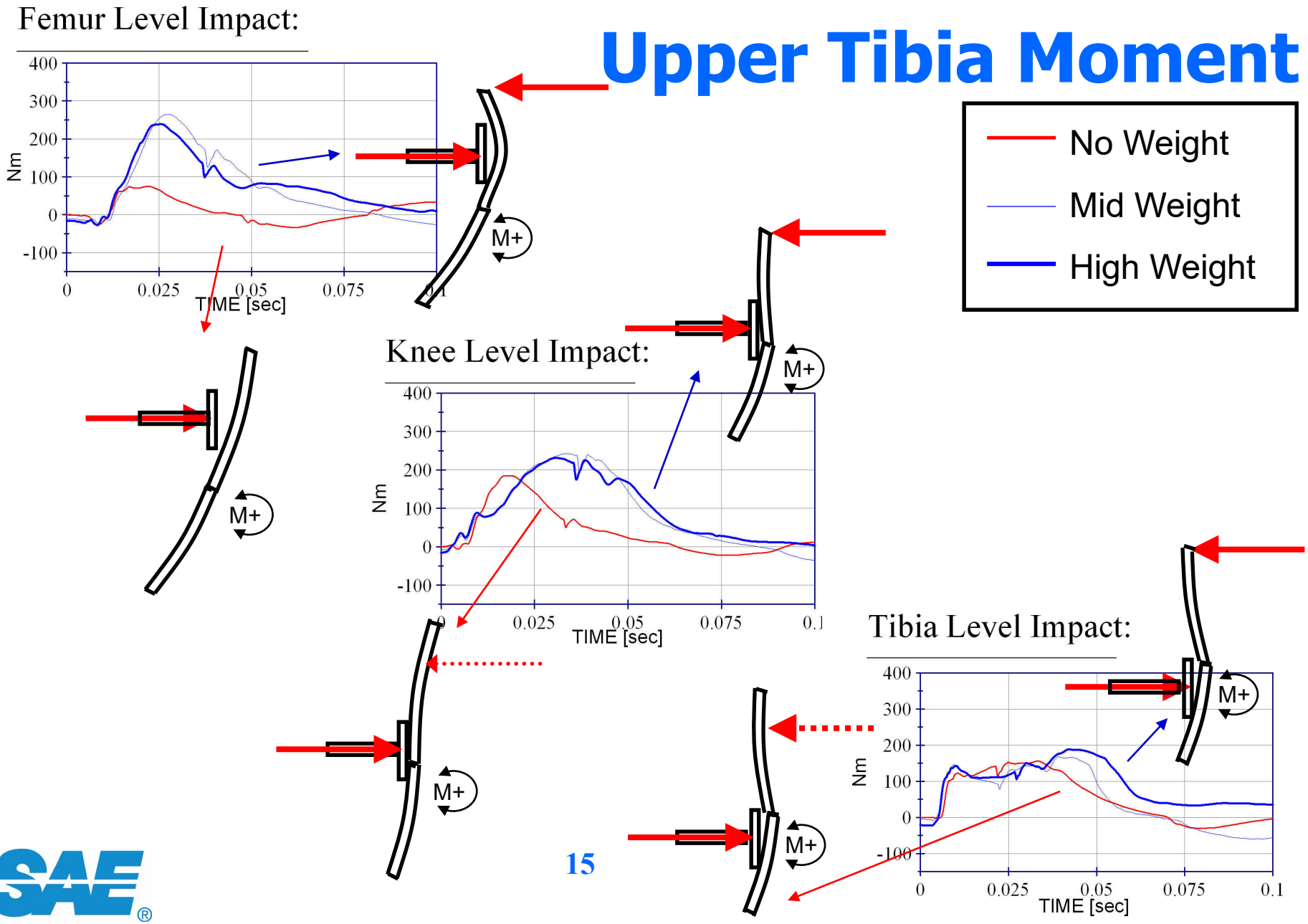



## Tibia Level Impact:



# *Inertial effects of upper body: Preliminary Results*

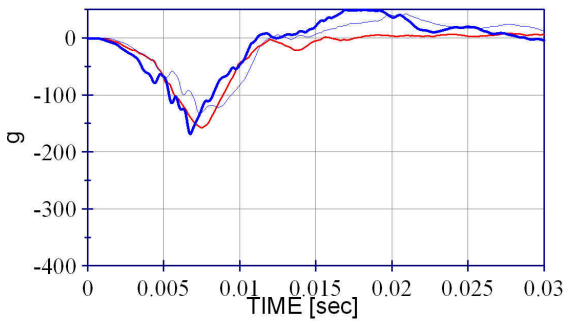
## Upper Tibia Moment



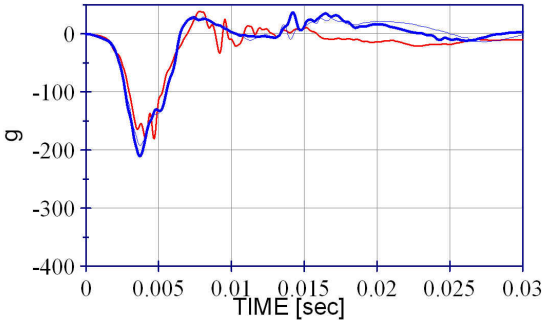
# *Inertial effects of upper body: Preliminary Results*

## Femur acceleration

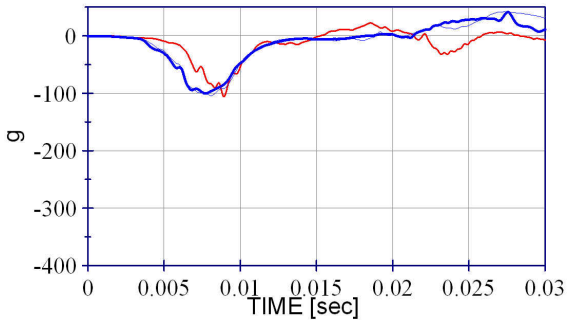
Femur Level Impact:




Knee Level Impact:




Tibia Level Impact:



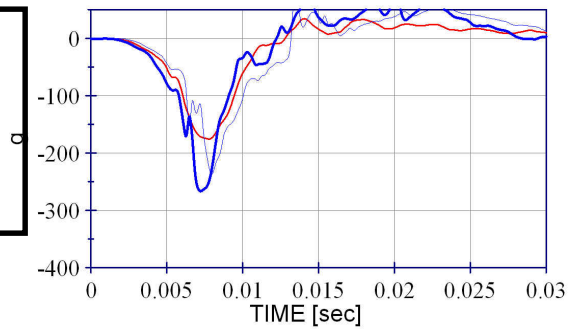

No Weight

Mid Weight

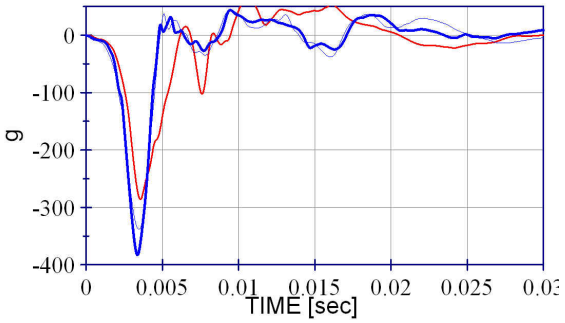
High Weight

## Tibia acceleration

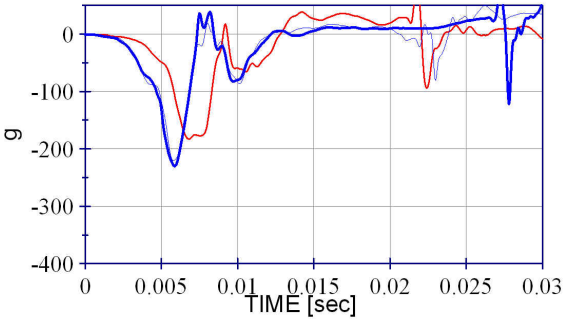
Femur Level Impact:




Knee Level Impact:




Tibia Level Impact:



# Preliminary Observations

1) Ground contact effects appear minimal.
2) Presence of body mass does have effect on bending moment.
   - Femur moment - all impact heights
   - Tibia moment - high-bumper impacts
3) Presence of body mass has less effect on acceleration.

# Implications for Test Procedure

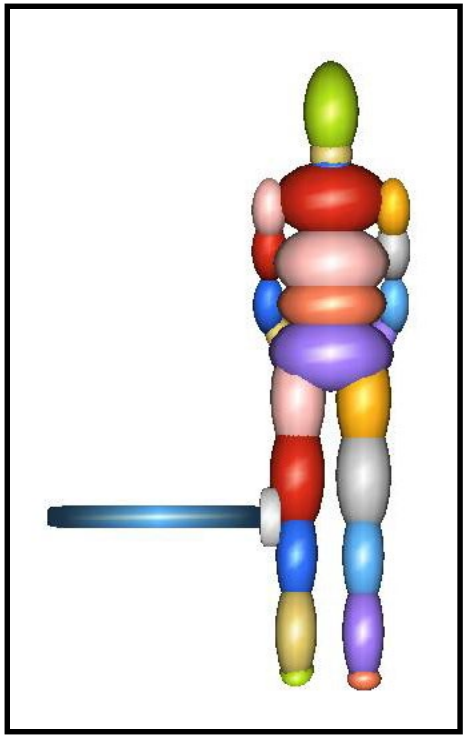
- Projectile test has potential to evaluate fracture measures
- Body weight effects on bending moment:
  - Limitations for unweighted projectile legform
- Future evaluation of bending moment should:
  - Be limited to impacts in certain height range

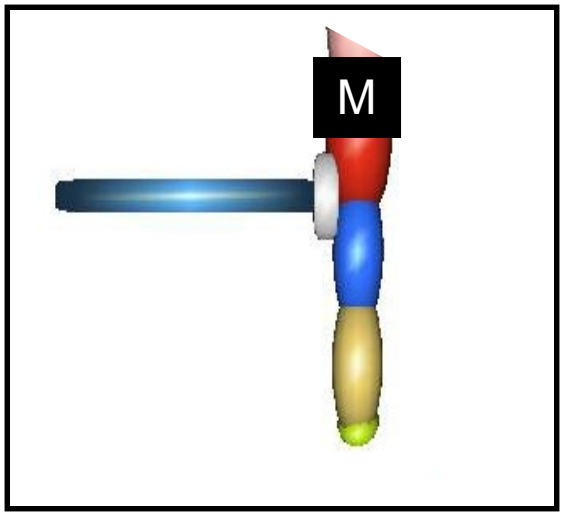
*Or*

  - Simulate the inertia of the upper body

# Future work

- Modeling
  - Determine added mass required to simulate whole body impact
  - Begin with mass recommended for knee injury measures.
- Testing
  - Modify legform with mass
  - Compare weighted leg with full-body tests





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