Characterizing the stiffness change of the proximal femur between quasi-static and dynamic loading in a fall configuration

Gilchrist S[1,2,3,‡], Guy P[3,4], Cripton P[1,2,3]
1: UBC Mechanical Engineering, 2: UBC Bridge Program
3: Centre for Hip Health and Mobility, 4: UBC Department of Orthopaedics

Introduction

- **Detect** – Prevent – Treat
- Detection is key to prevention
  - aBMD predicts <30% of fractures [1].
  - New imaging may change that – we need to be prepared!
- Understand mechanism
  - Current lab models are quasi-static.
  - Clinical fractures are dynamic.

Objective

To determine if loading behaviour of the proximal femur is different under quasi-static loading and simulated fall conditions.

Methods

- 17 fresh frozen femurs DXA scanned.
- Tested at 0.5 mm/s in a materials testing machine to 50% DXA predicted failure.
- Tested in a fall simulator with impact at 3 m/s [2].
- Fall simulator body representation:
  - Body mass – 32 kg [3]
  - Soft tissue – 18 mm foam [3]
  - Pelvis – 50 N/mm spring [3]
  - Pelvis & femur inertia compensation [4]

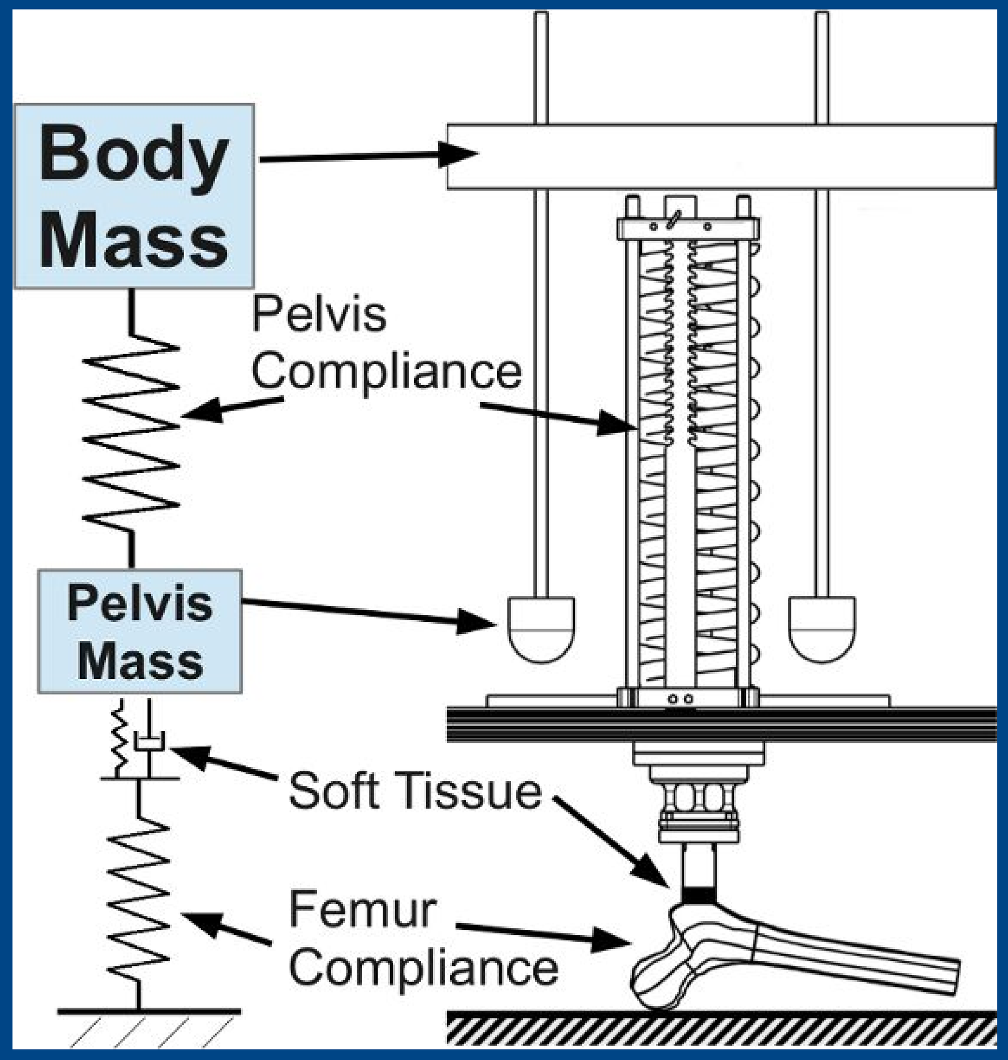

Figure 1: The lumped parameter model used to simulate a fall with an impact on the side. The impact of the body mass is attenuated by the compliance of the pelvis, while the pelvis and femur mass bypasses the pelvis compliance to deliver a shock load similar to that seen in automotive side impact testing [5].

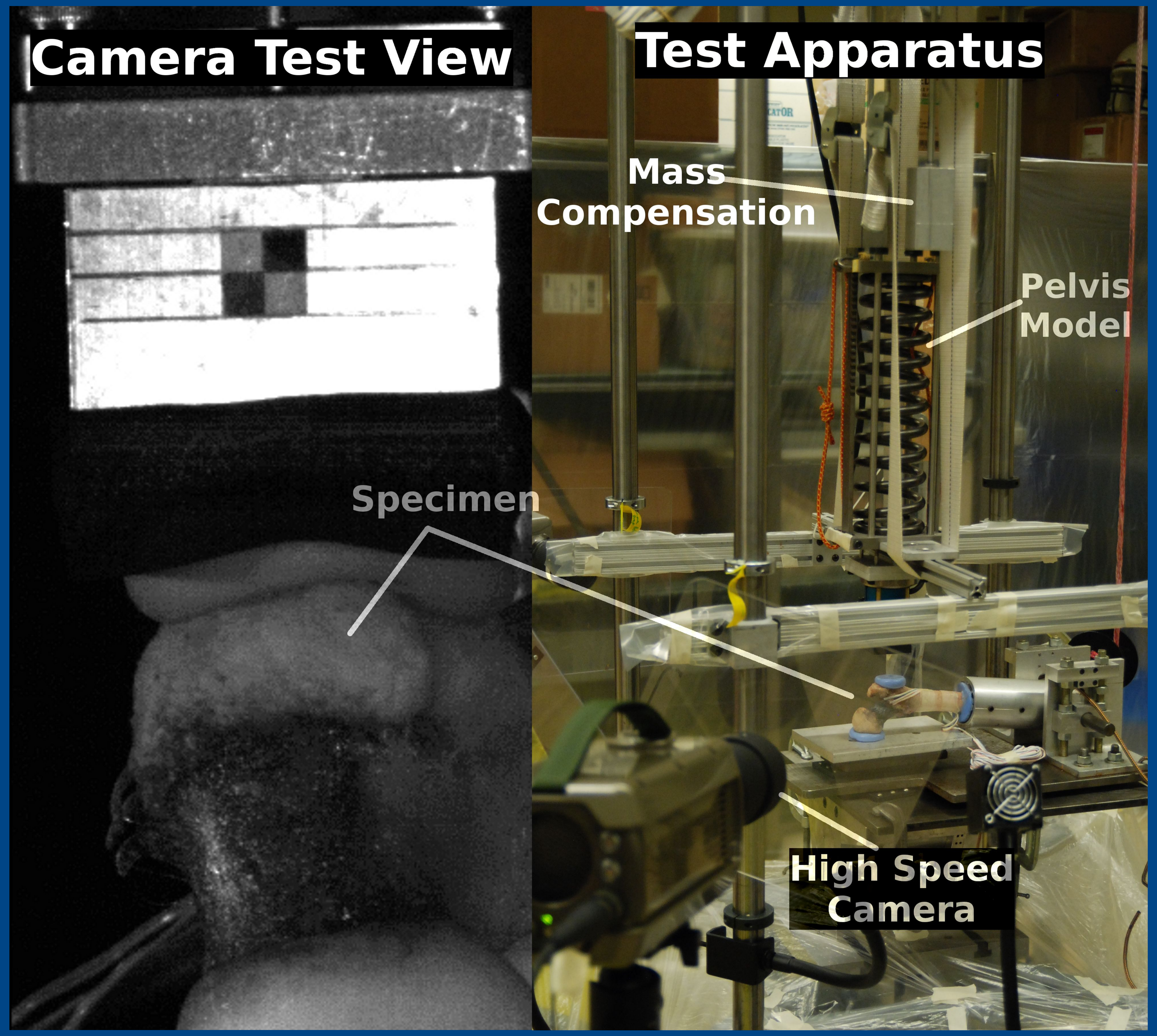

Figure 2: (Left) A Sample view from the displacement measurement camera. The tracking marker on the impactor and the interface between the trochanter and the PMMA pad were tracked. (Right) The fall simulator showing the pelvis spring model, pelvis mass compensation, specimen and one of the high speed cameras.

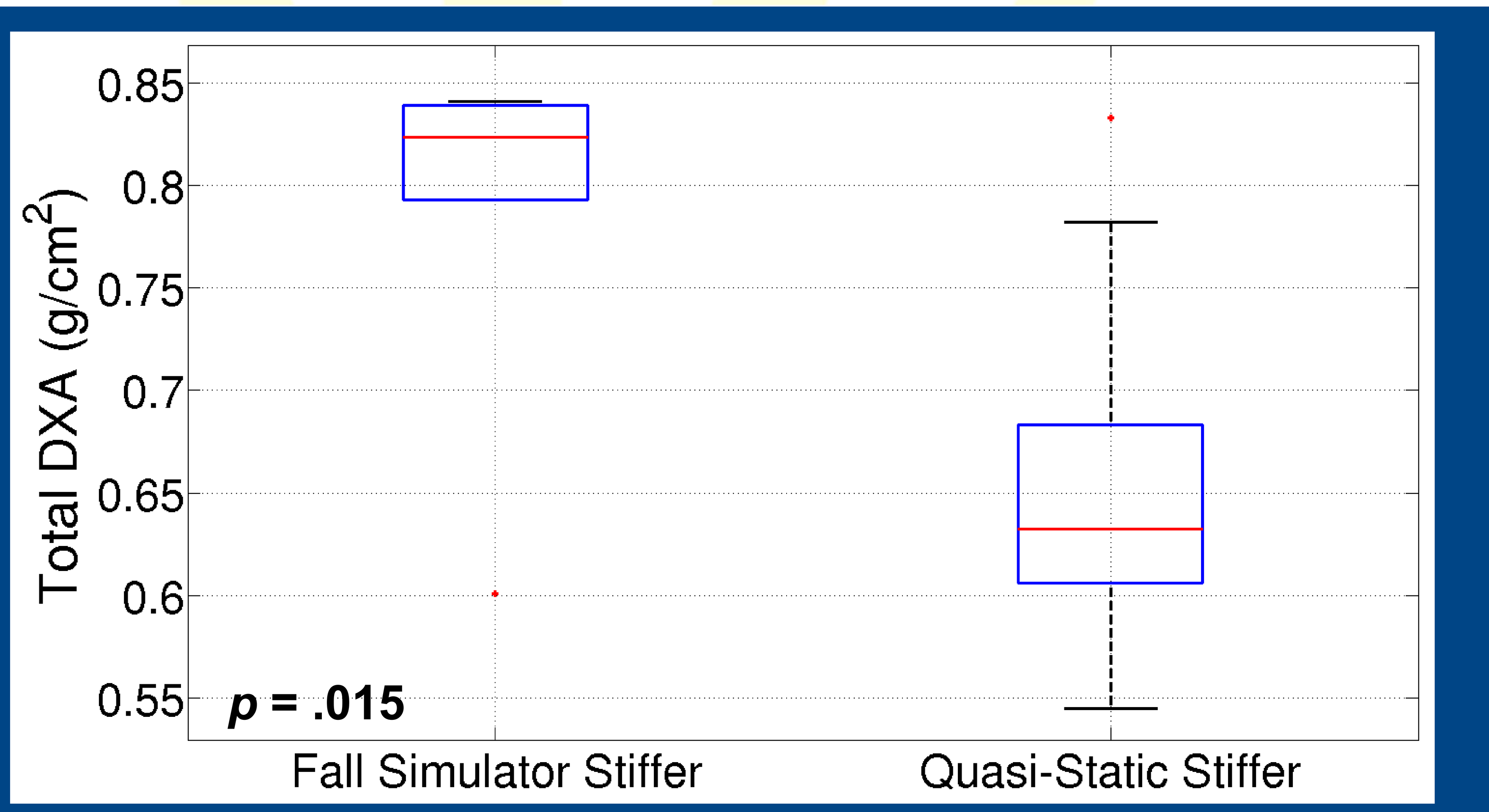

Figure 3: Total DXA for specimens grouped by relative stiffness in the fall simulator vs the quasi-static test. The DXA values between the groups were different by 0.13 g/cm^2 (95% CI = [0.02,0.23]).

Results

- Higher DXA femurs became stiffer when tested in the fall simulator (p = 0.015).
- Stronger femurs became stiffer when tested in the fall simulator (p < 0.001).
- Energy absorption to fracture was not different when grouped by relative stiffness (p = 0.16).

Conclusion

Proximal femur loading mechanics are affected by the testing method in a significant way. Intrinsic properties (e.g. DXA) play a part in determining how the bone will react to different loading scenarios.

References

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‡Corresponding Author: seth@mech.ubc.ca

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