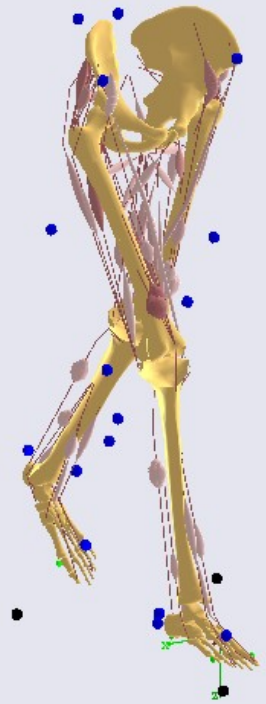
Validation of Hip Joint Force Simulation by Gait Analysis

Catherine Manders



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(Presenter)

Søren Tørholm
(Panelist)

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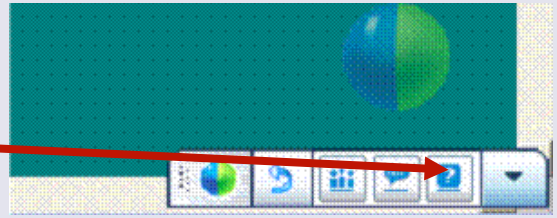

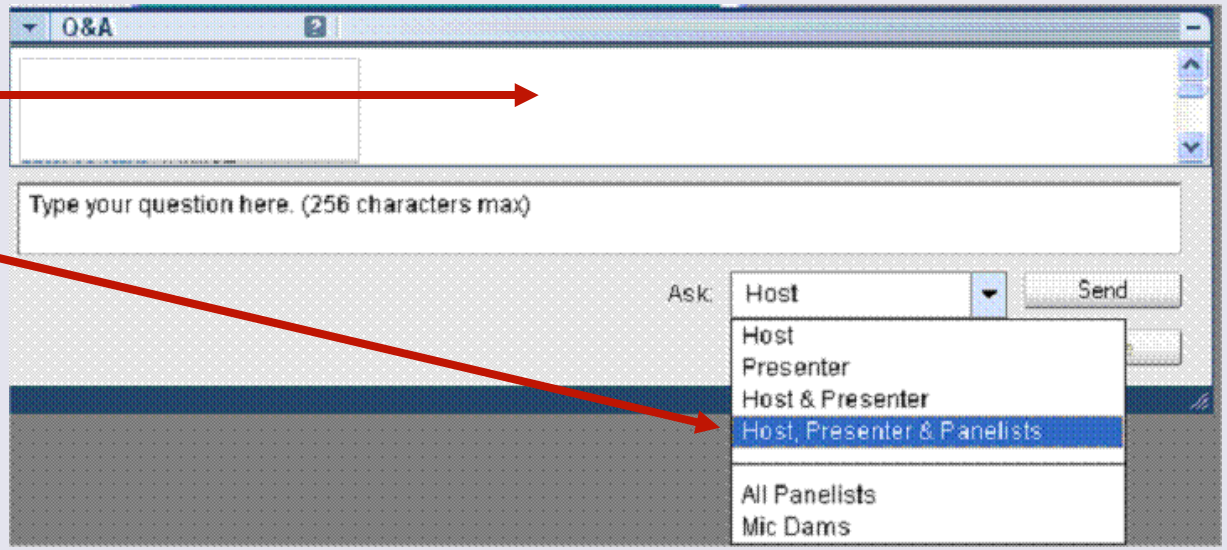

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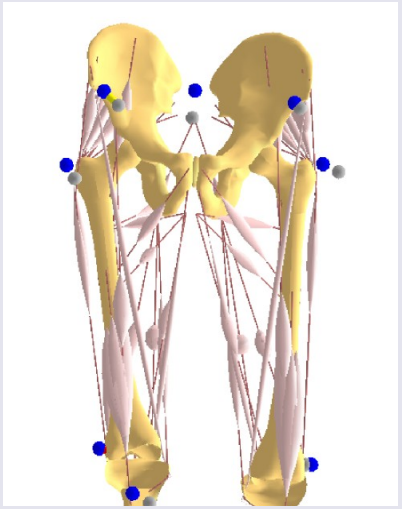
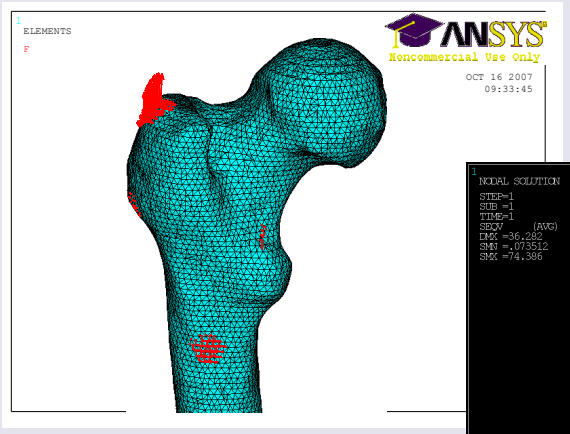
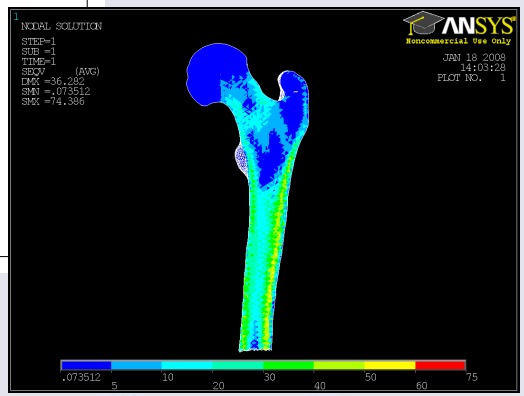
ANYBODY TECHNOLOGY

Introduction

- Combining musculoskeletal and FE analysis in relation to total hip replacement
- Use muscle and contact forces from AnyBody
- Apply forces to ANSYS model of femur and prosthesis







[1] Ek, E.T. and Choong, P.F.M. (2005) J. Athro 20(1) 94-100

ANYBODY TECHNOLOGY

Introduction

- Model
  - Input Data
  - Gait model
  - Muscle recruitment
- Validation
  - Hip contact forces
  - Torque
- Conclusion

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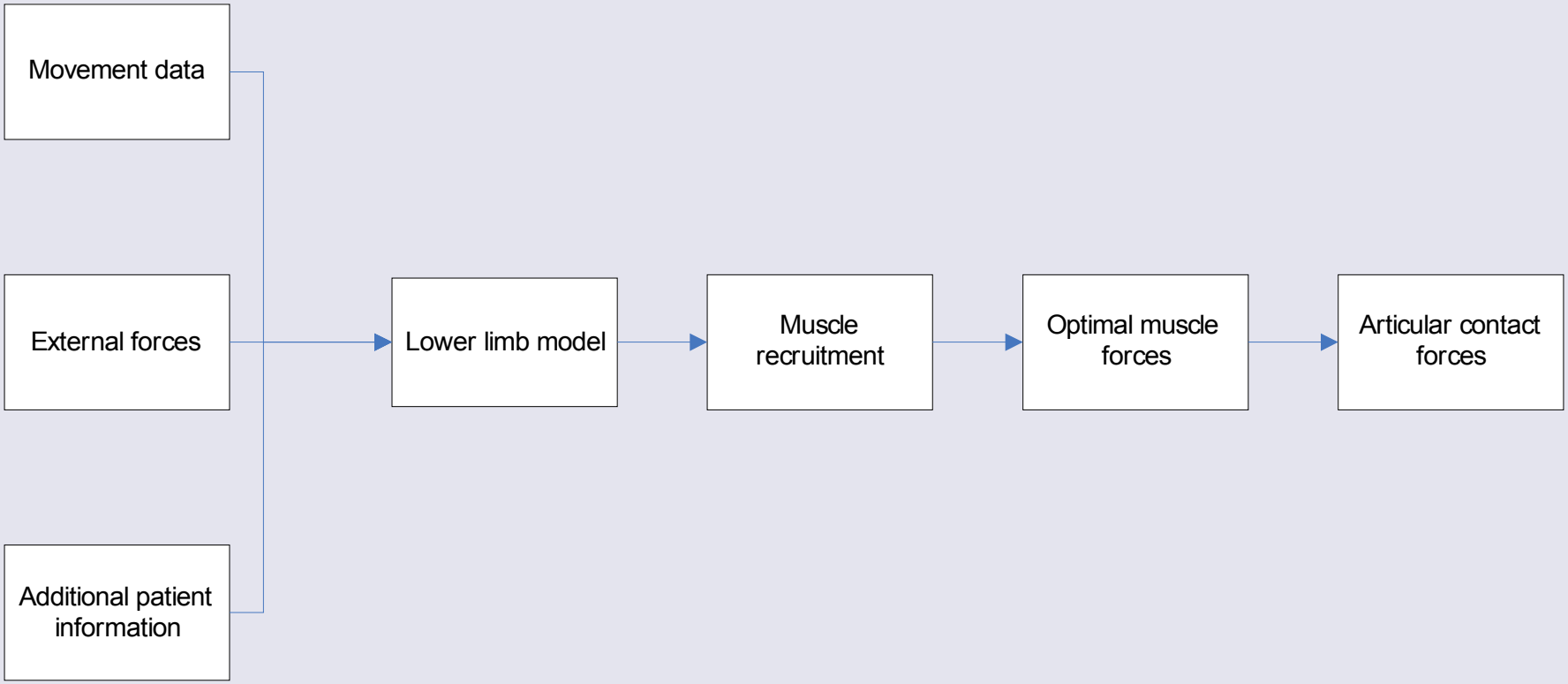
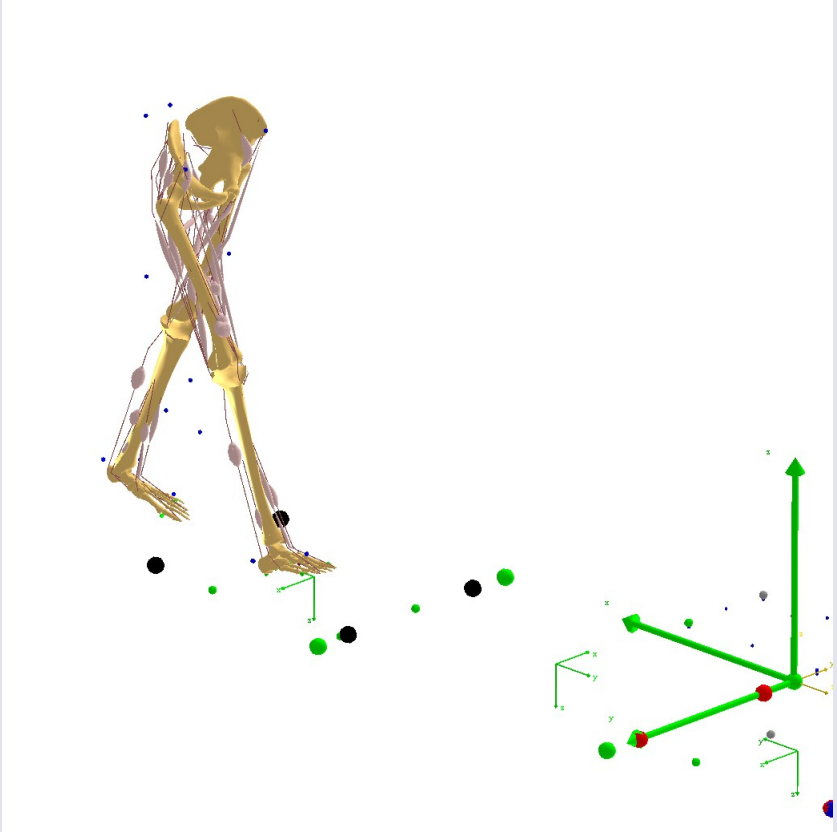
AnyBody



ANYBODY TECHNOLOGY

Gait Model

- Normal gait analysis from University of Miami[1] and from Vaughan et al[2]
- Marker positions recorded

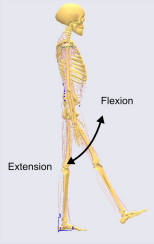


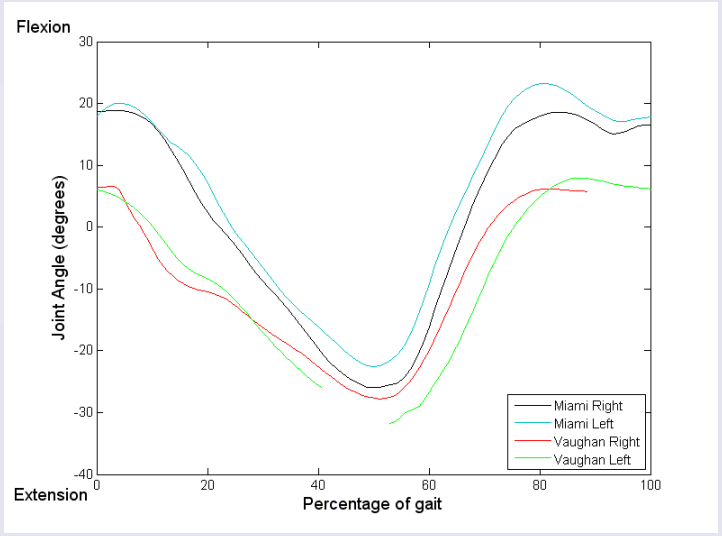
1 **Asfour, S. and Eltoukhy, M., Department of Industrial Engineering, University of Miami. Personal Communication**

2 **Vaughan, C.L., Davis, B.L., et al. (1992) *Dynamics Of Human Gait*. 2nd ed., Cape Town, South Africa: Kiboho Publishers.**

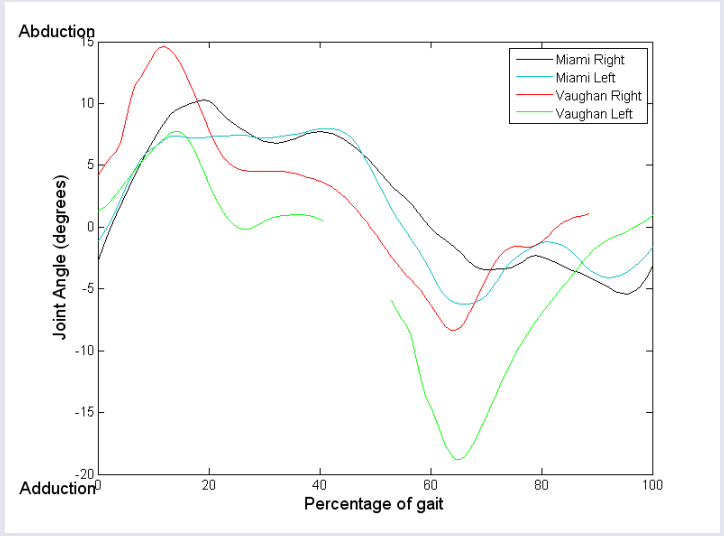
ANYBODY TECHNOLOGY

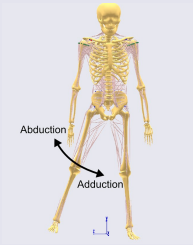
Input Data



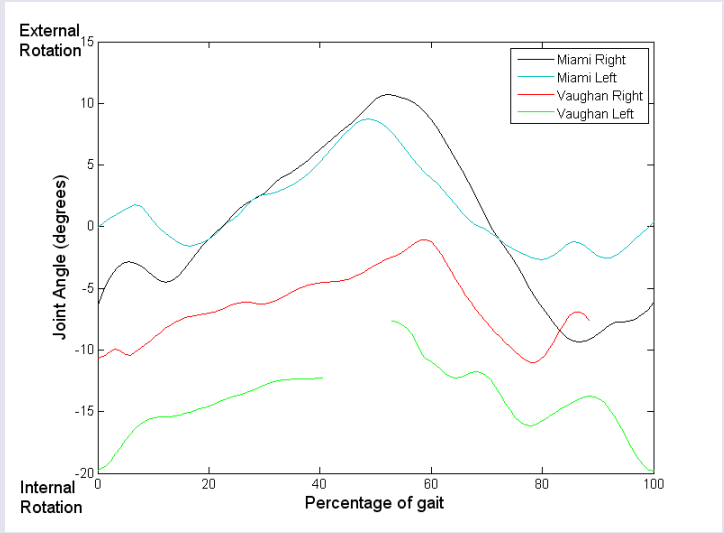


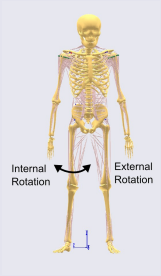
Flexion





Abduction



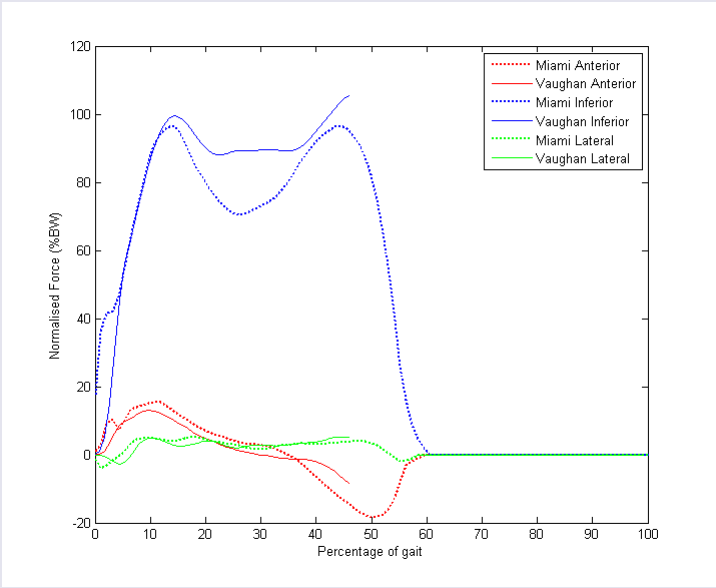


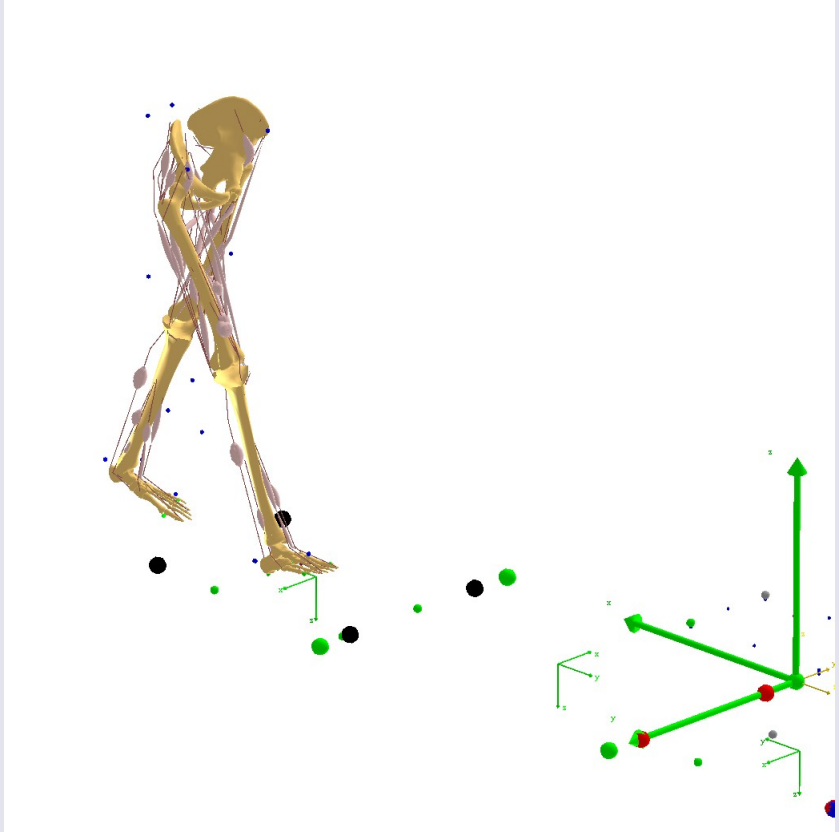
External Rotation

ANYBODY TECHNOLOGY

Gait Model

- Normal gait analysis from University of Miami[1] and from Vaughan et al[2]
- Marker positions recorded
- Force plate data





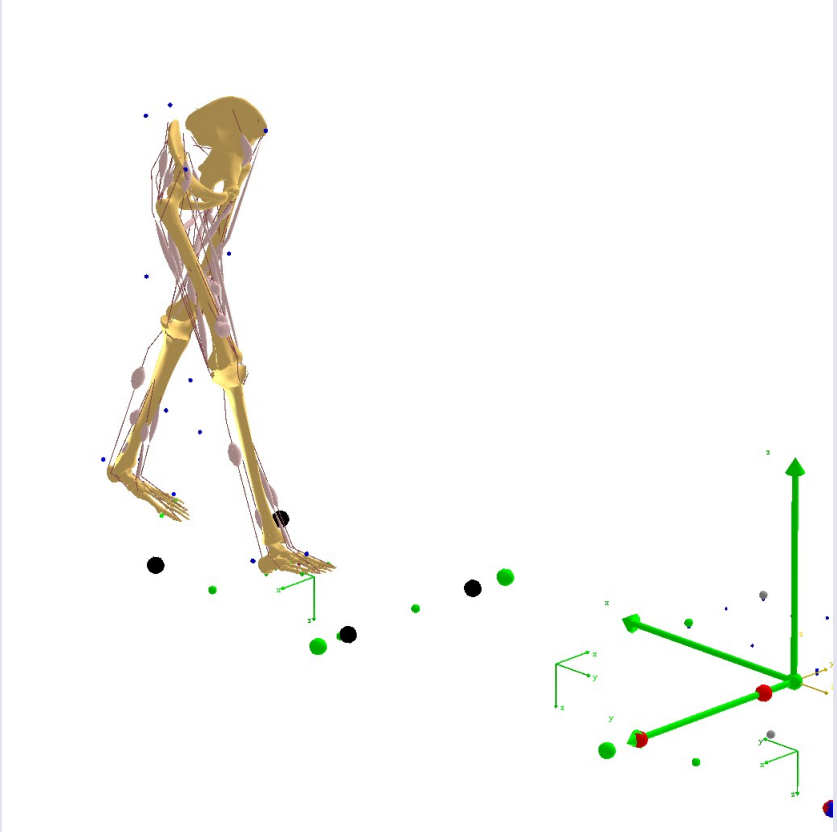
[1] **Asfour, S. and Eltoukhy, M., Department of Industrial Engineering, University of Miami. Unpublished Work**

[2] **Vaughan, C.L., Davis, B.L., et al. (1992) *Dynamics Of Human Gait*. 2nd ed., Cape Town, South Africa: Kiboho Publishers.**

ANYBODY TECHNOLOGY

Gait Model

- Normal gait analysis from University of Miami[1] and from Vaughan et al[2]
- Marker positions recorded
- Force plate data
- Model of lower extremity



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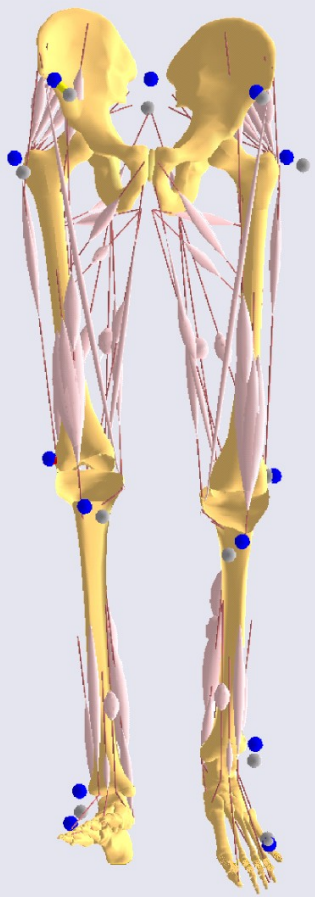
Gait Model

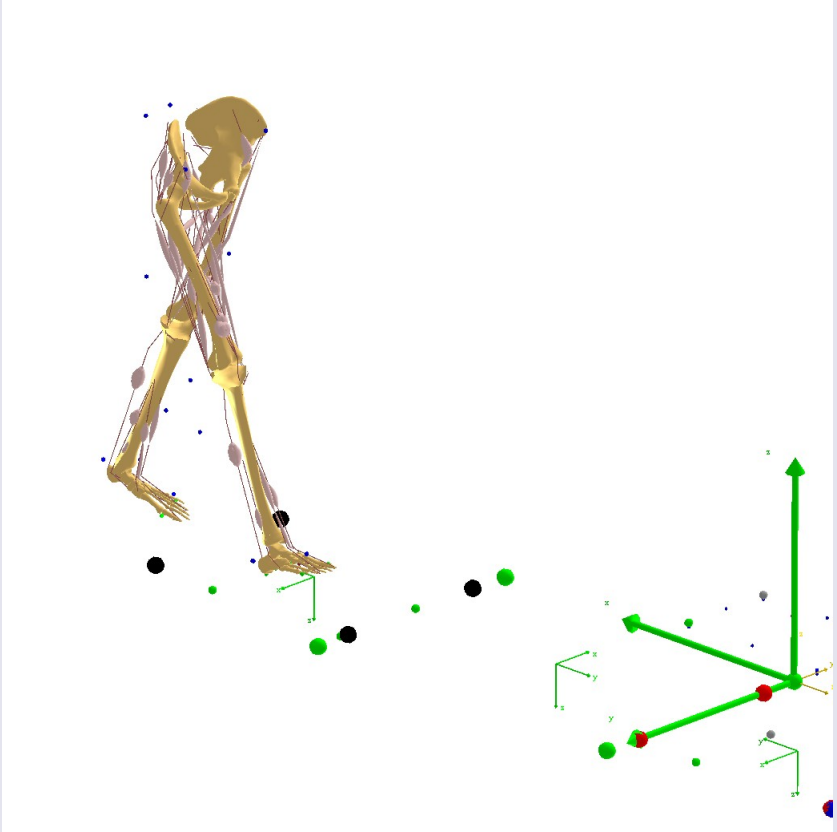


- Joints
  - Hips – ball and socket
  - Knees – hinge joint
  - Ankle – universal joint
- 70 muscle units based on Hill type model
- Scaled to fit the measured subject
- Driven by marker positions

ANYBODY TECHNOLOGY

Gait Model

- Normal gait analysis from University of Miami[1] and from Vaughan et al[2]
- Marker positions recorded
- Force plate data
- Model of lower extremity
- Muscle recruitment



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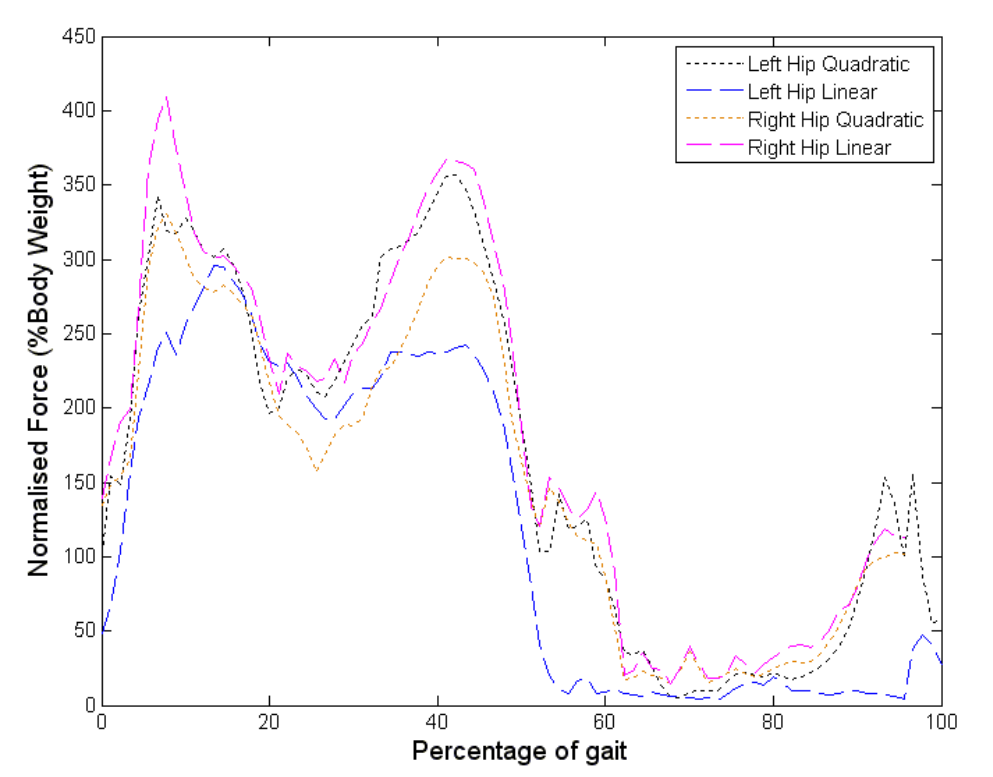
Gait Model



Resultant Force at the Hip in Miami Model

Muscle recruitment

Linear:
Minimise maximum muscle activity

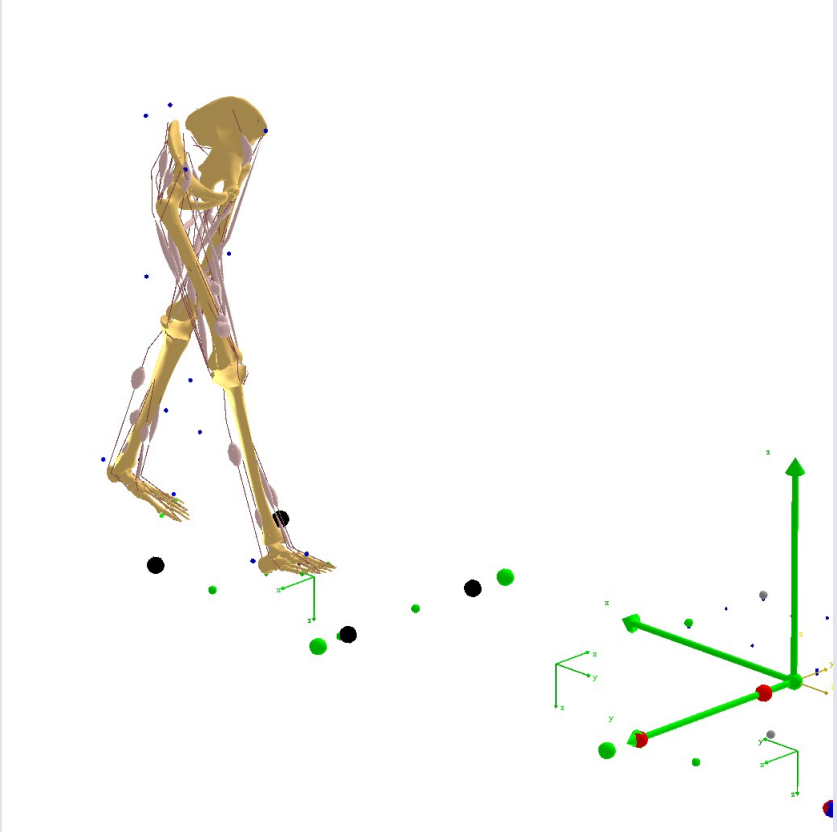
Quadratic:
Minimise Σ (muscle activities^2)

Activity = force/strength

ANYBODY TECHNOLOGY

Gait Model

- Normal gait analysis from University of Miami[1] and from Vaughan et al[2]
- Marker positions recorded
- Force plate data
- Model of lower extremity
- Muscle recruitment
  - Minimise Σ (muscle activities^2)
  - Activity = force/strength
- Output
  - Muscles forces
  - Hip contact force
  - Torque at hip (calculated without muscles)



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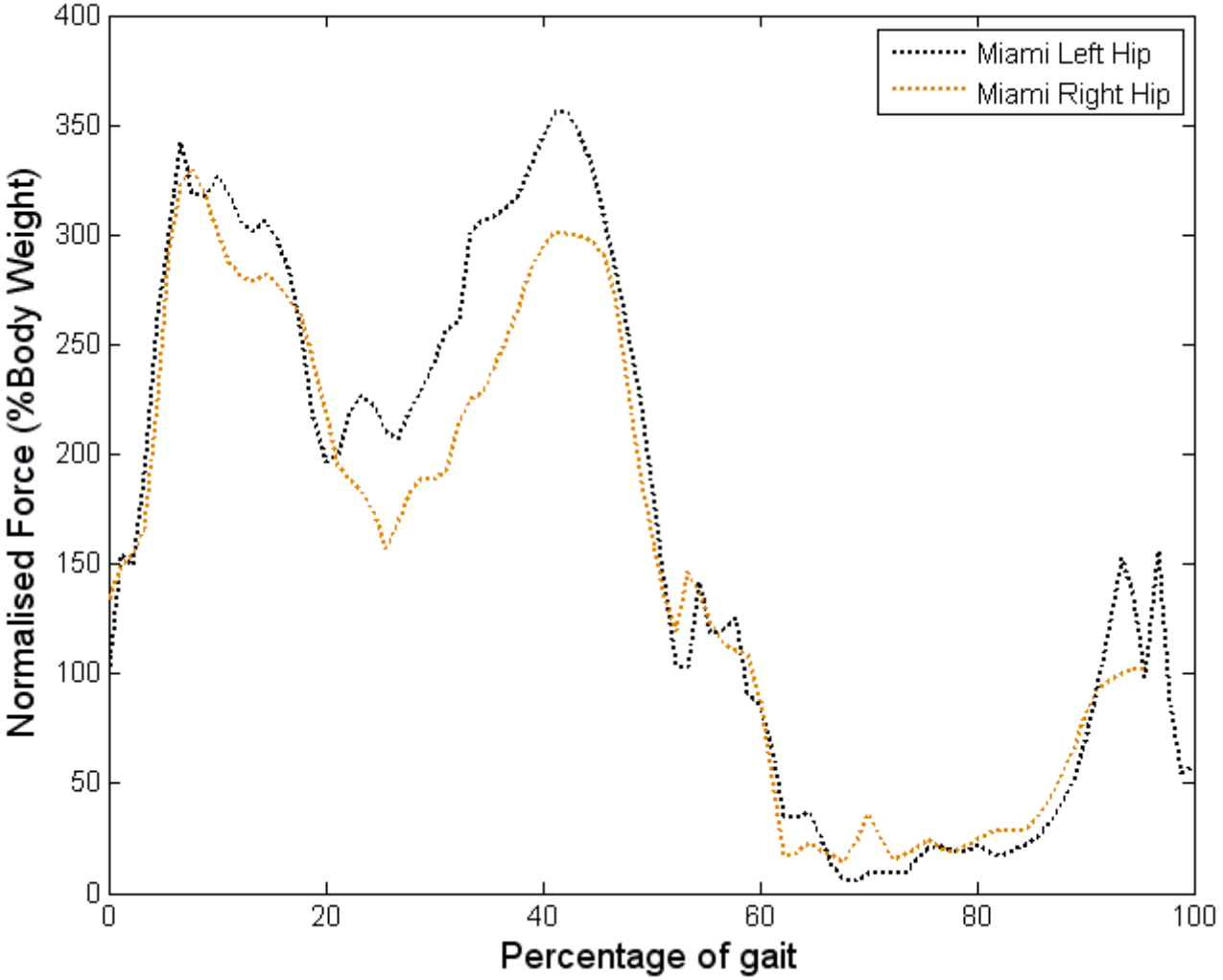
Validation

- Compared hip contact force from models to measured hip force
- Bergmann et al[1] and Brand et al[2] measured hip contact force with instrumented hip replacements
  - Range of force from several gait cycles

[1] Bergmann, G., Deuretzbacher, G., et al. (2001) *Hip Contact Forces And Gait Patterns From Routine Activities.* Journal of Biomechanics. **34**: p. 859-871.

[2] Brand, R.A., Pedersen, D.R., et al. (1994) *Comparison Of Hip Force Calculations And Measurements In The Same Patient.* The Journal of Arthroplasty. **9**(1): p. 45-51.



Resultant Force at the Hip

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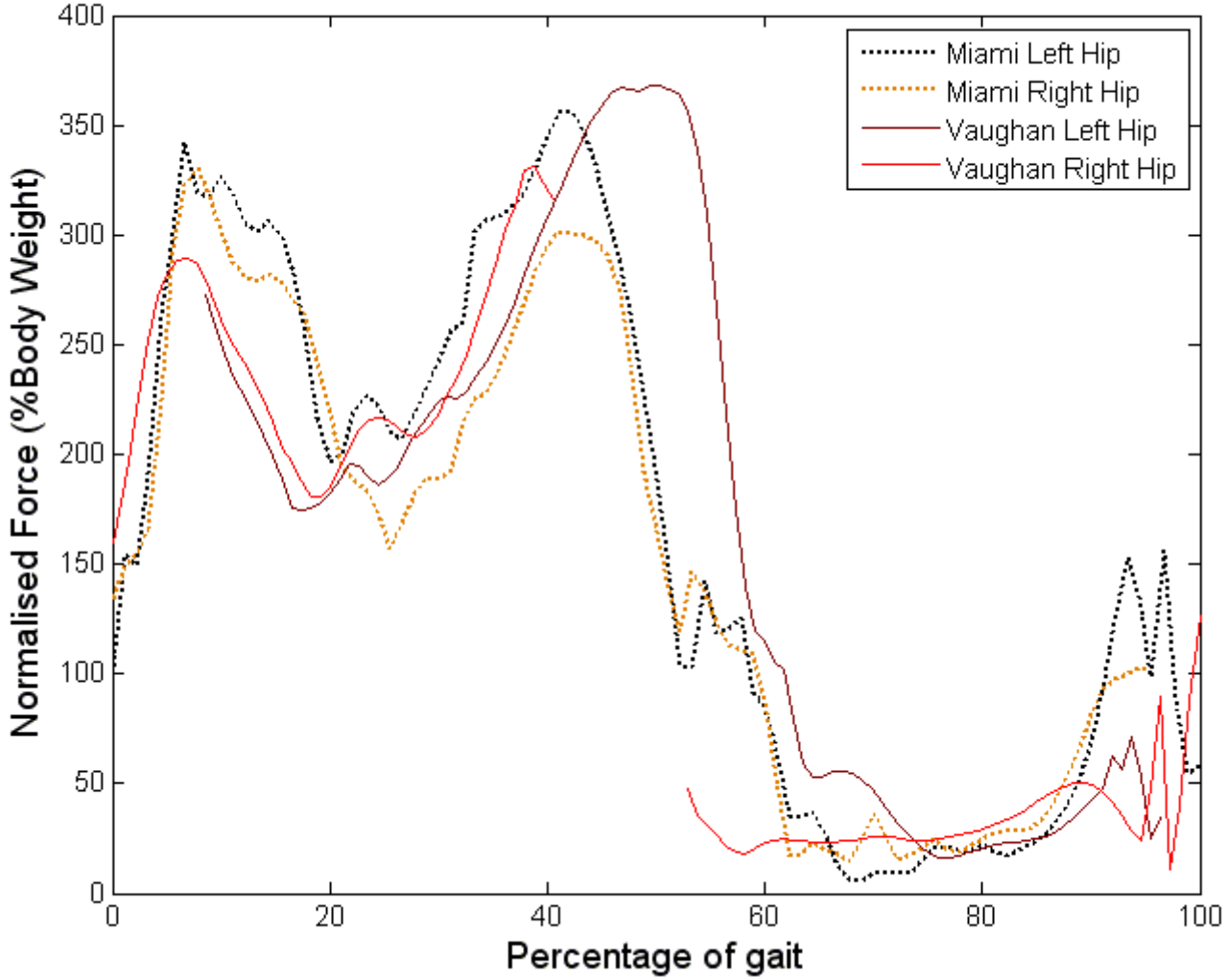

Resultant Force at the Hip

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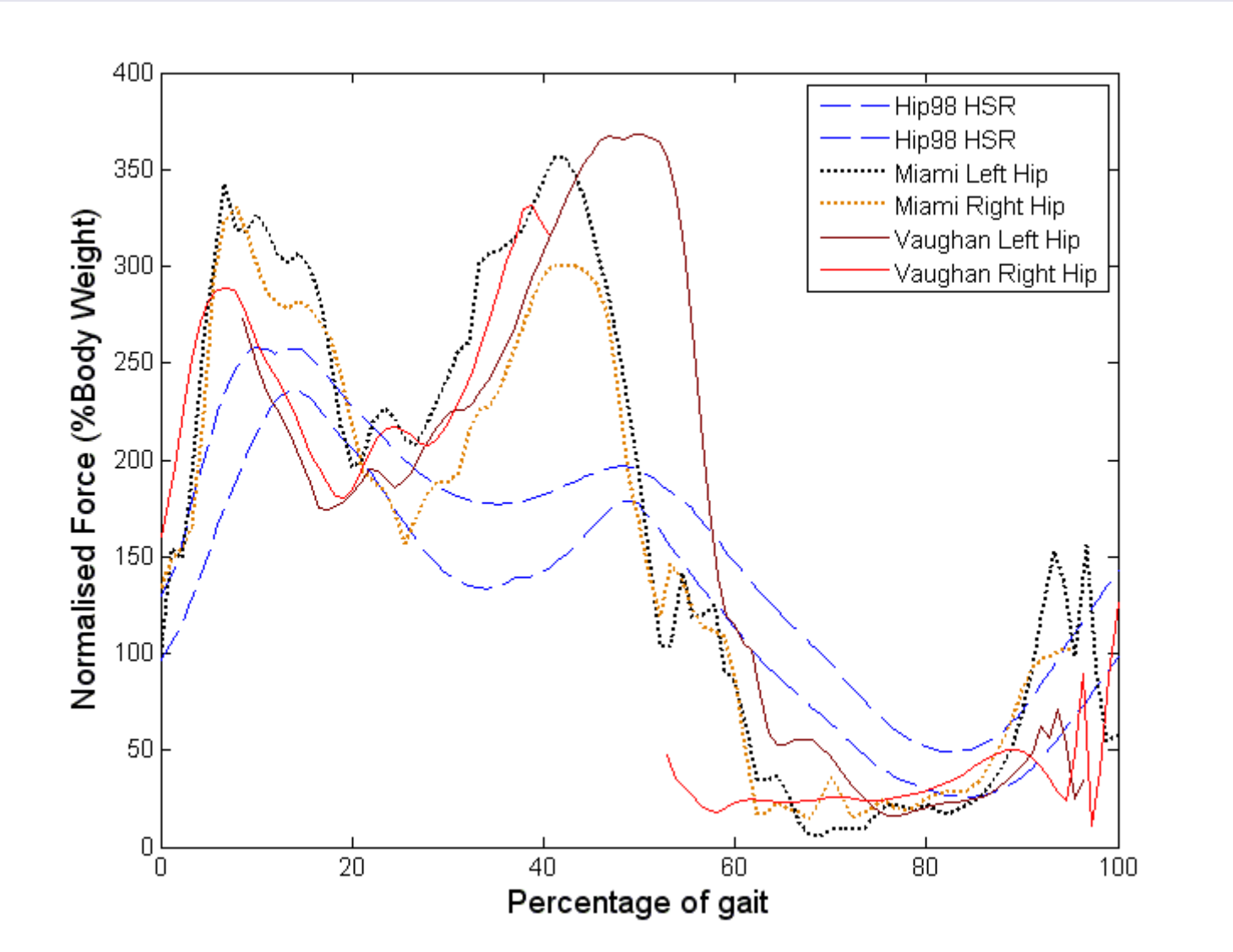

Resultant Force at the Hip

Bergmann, et al. (2001) J. Biomech.
34:859-871

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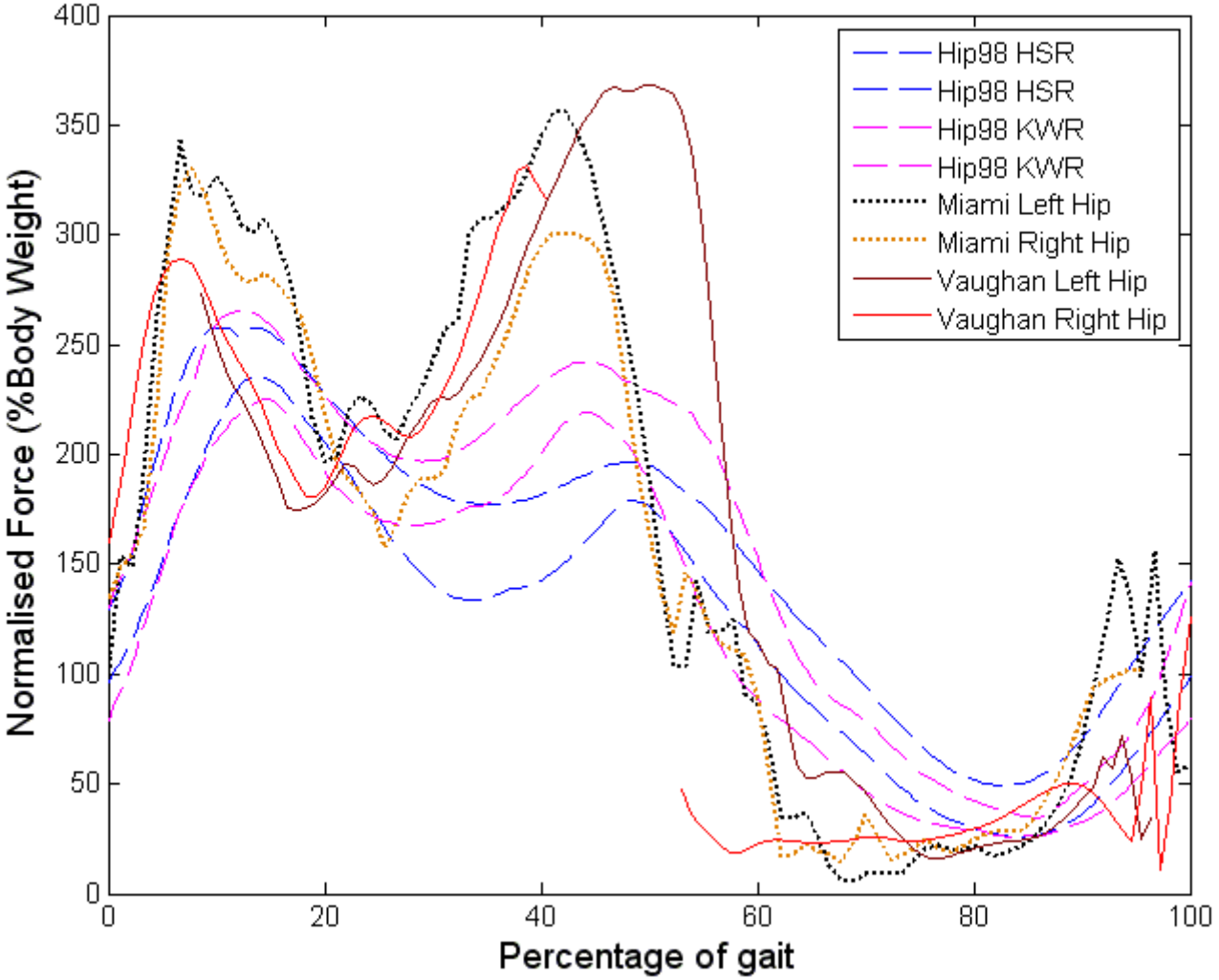

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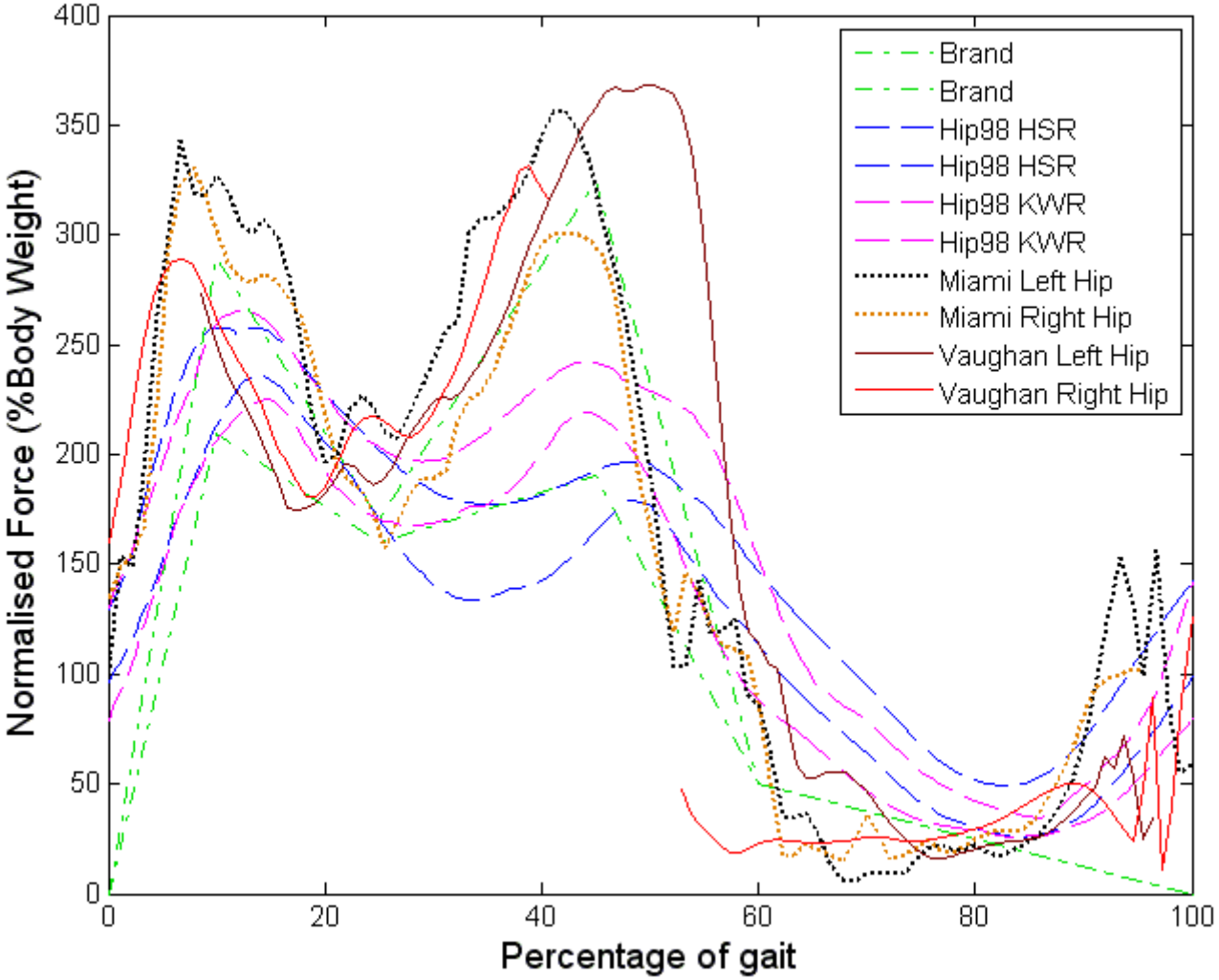

Brand, et al. (1994) J. Arthro. **9**(1)45-51

Bergmann, et al. (2001) J. Biomech. **34:**859-871

Resultant Force at the Hip

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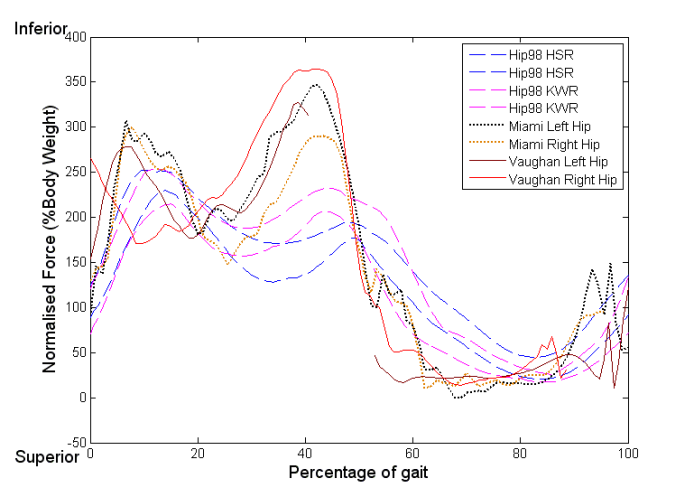
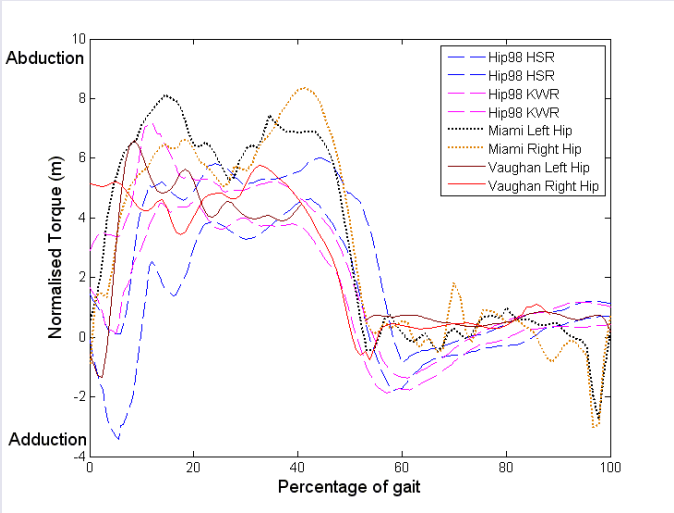
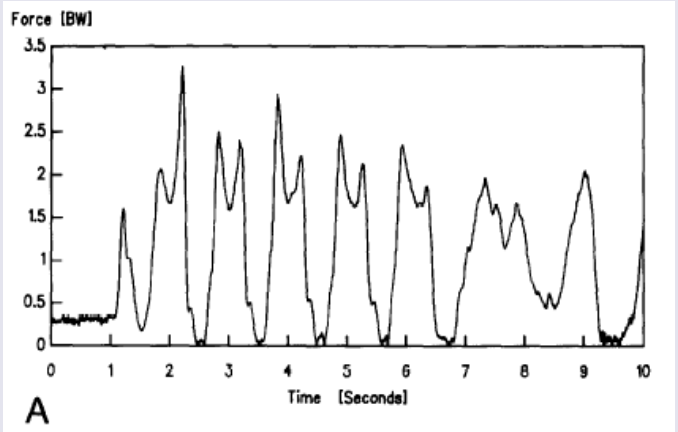
Validation

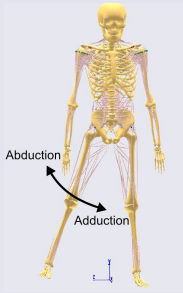




Axial Force

Abduction Torque





Resultant force measured with an instrumented hip implant

Brand, et al. (1994) J. Arthro. **9**(1)45-51

Bergmann, et al. (2001) J. Biomech. **34:**859-871

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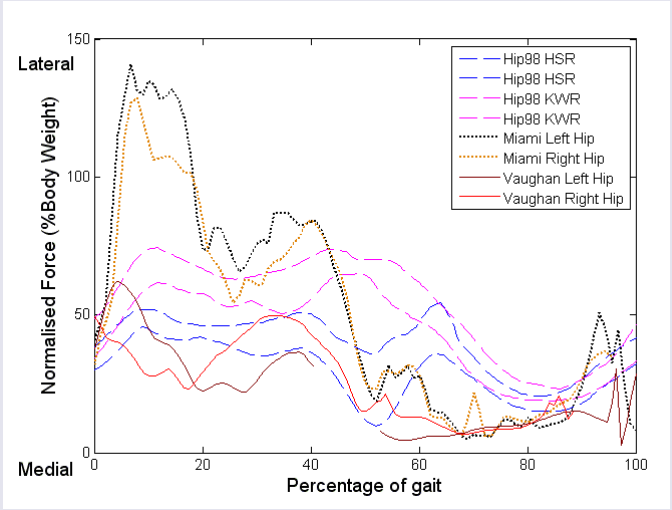
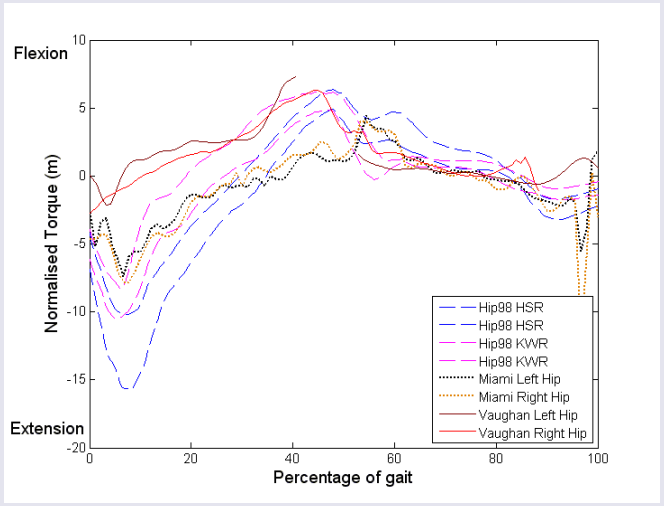
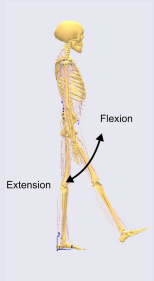
Validation

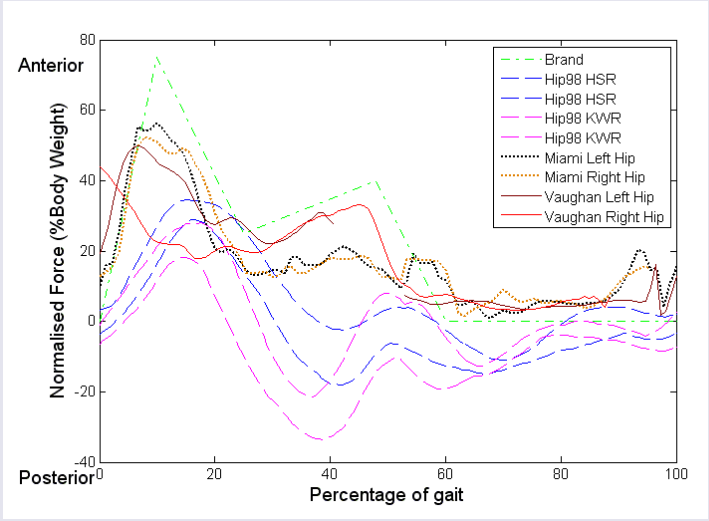


Lateral Force

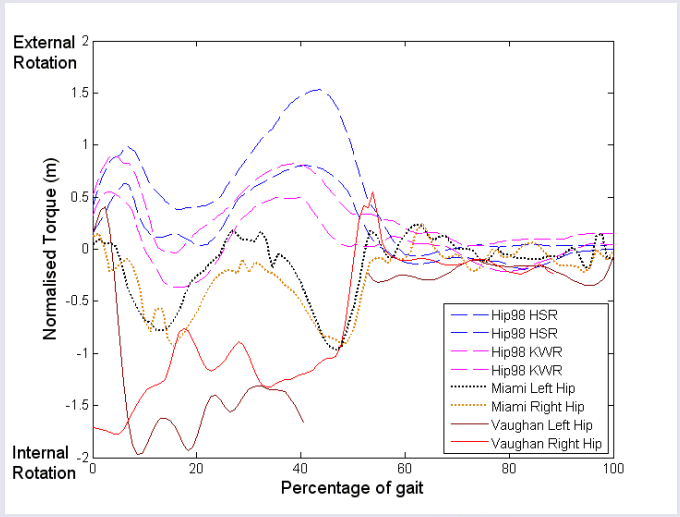


Flexion Torque

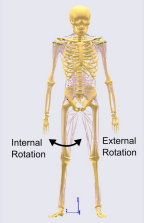




Anterior Force



Rotational Torque



Brand, et al. (1994) J. Arthro. **9**(1)45-51

Bergmann, et al. (2001) J. Biomech. **34:**859-871

ANYBODY TECHNOLOGY

Summary

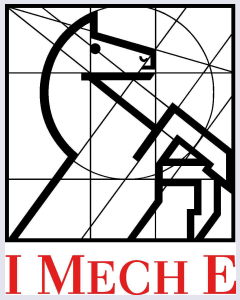
- Overall good correlation
- Some discrepancies between calculated and measured forces
- Large forces and large joint torques
- Some variation between patients and large stride to stride variation

Acknowledgments

Dr Andrew New
Prof. Mark Taylor

Prof. John Rasmussen

Dr Shihab Asfour
Moataz Eltoukhy



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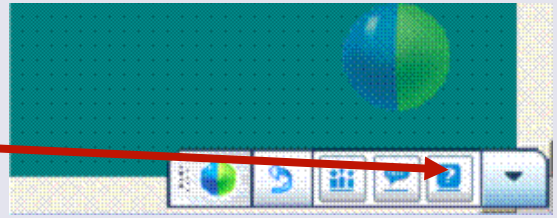

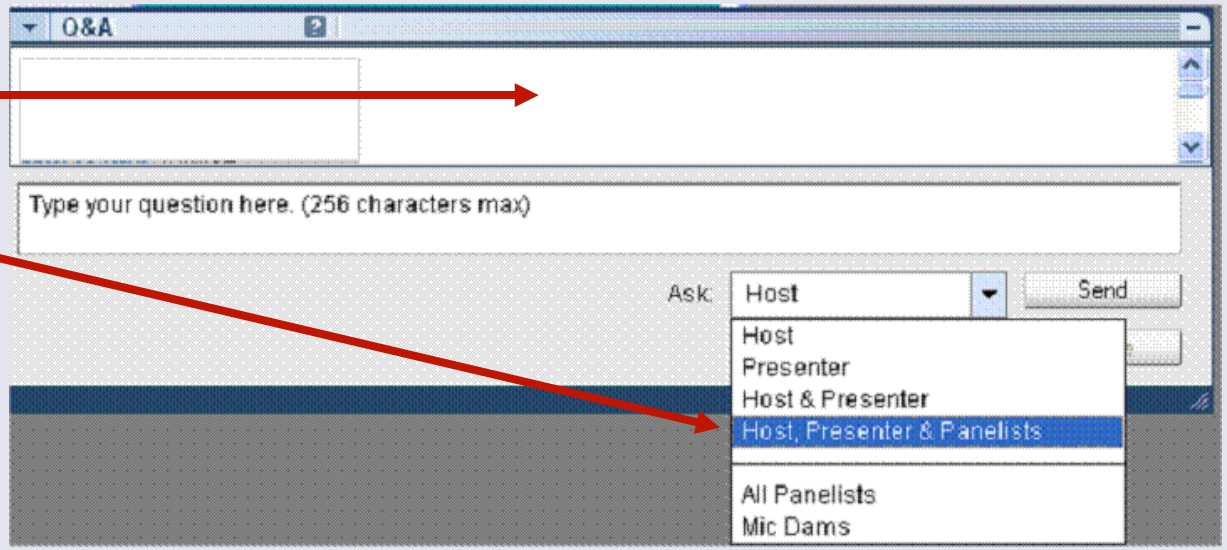

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