Induced acceleration contributions to locomotion dynamics are not physically well-defined

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Introduction

Induced acceleration (IA) analyses

- Quantifies contributions of individual forces and moments to accelerations, reaction forces, and powers produced during a task
- Decomposition based on instantaneous effect of applying individual forces to a dynamic model
- Because of dynamic coupling, contributions often non-intuitive

IA analyses of locomotion

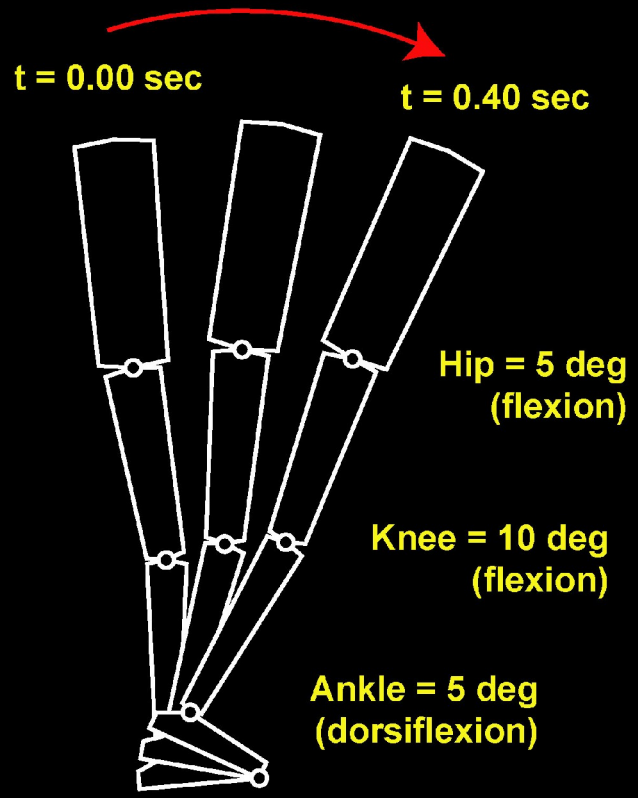
- Analysis has been used to assess muscle/joint moment function during locomotion
  - Vertical/forward acceleration of trunk or center of mass
    - Kepple, 1997; Neptune, 2001, 2003; Riley, 2001; Anderson, 2003; Zajac, 2003;
  - Mechanical powers of trunk and legs
    - Neptune, 2001, 2003; Zajac, 2003
- Can infer muscle coordination principles and potentially assist diagnosis of gait pathologies

IA contributions physically well-defined?

- Results and interpretations have differed between studies -> Controversy
- Are contributions well-defined or do they depend very much on formulation of model?
- In this study, assessment made possible by analyses of a simple, theoretical locomotor task using different models

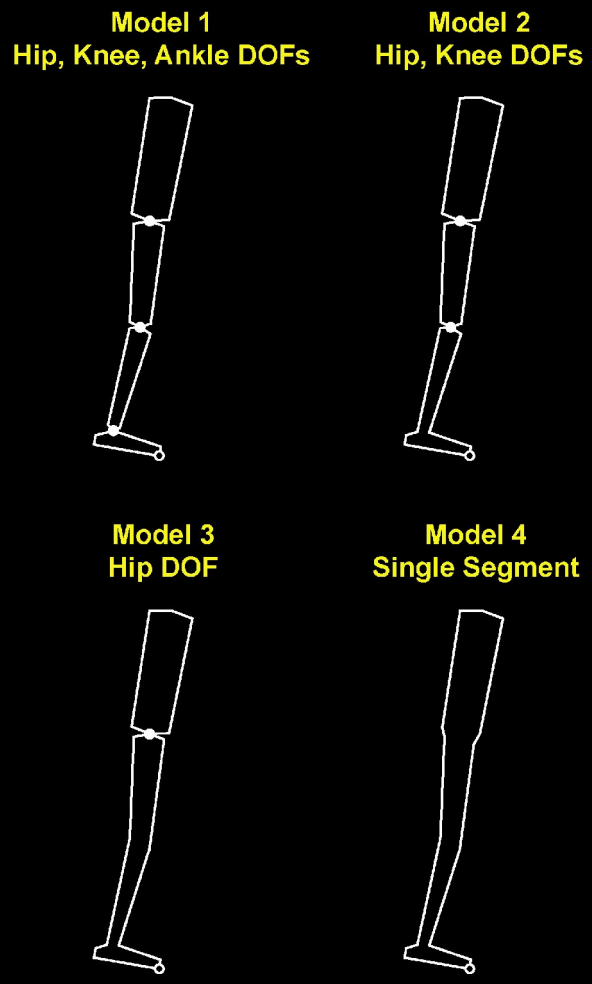
Methods

Theoretical locomotor task



- Based on a planar, rigid body simulation
- Four segments – Trunk, thigh, shank, and foot of supporting leg
- Joint moments prescribed to maintain configuration of body as it rolled forward over pin joint

IA analyses using 4 models

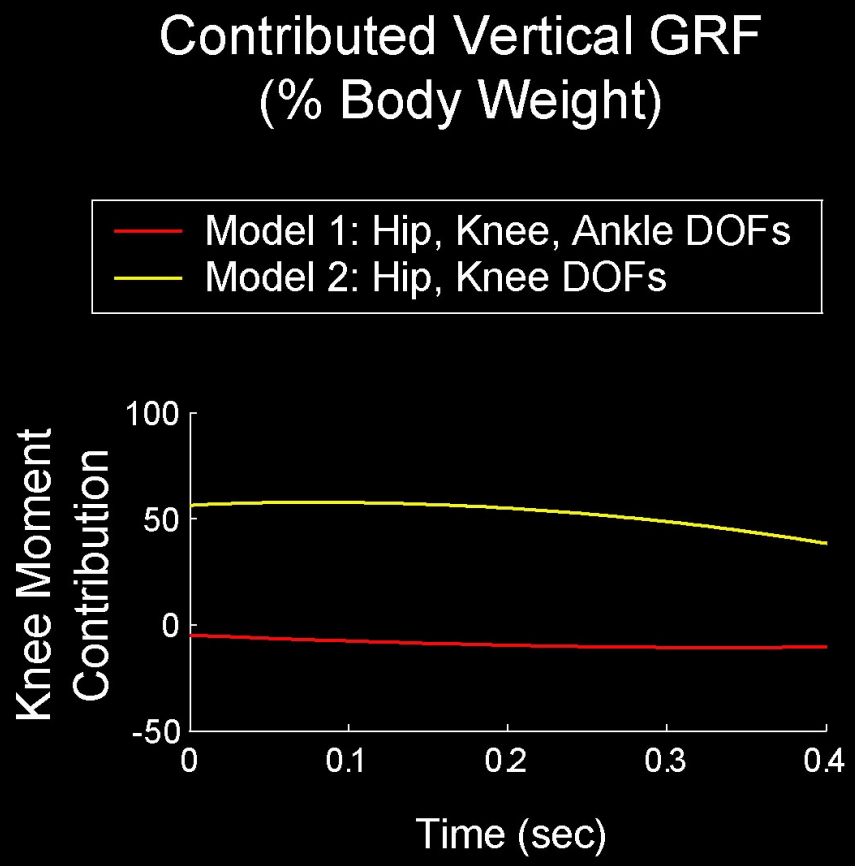


- Contributions of joint moments and gravity and centrifugal forces to
  - Vertical/ Horizontal GRF
  - Mechanical powers of trunk and leg
- Models 1 through 4
  - Represented progressively fewer degrees of freedom
  - All described simulated task dynamics

Results

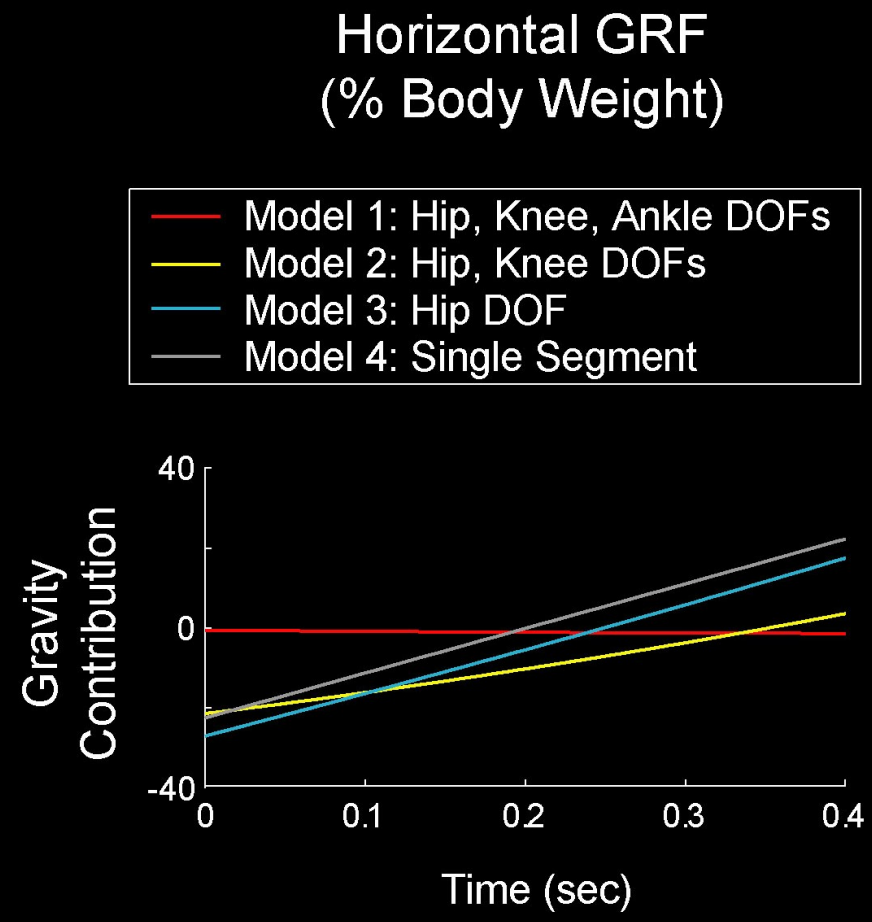
Vertical GRF contributed by each moment/force differed between models

Example:



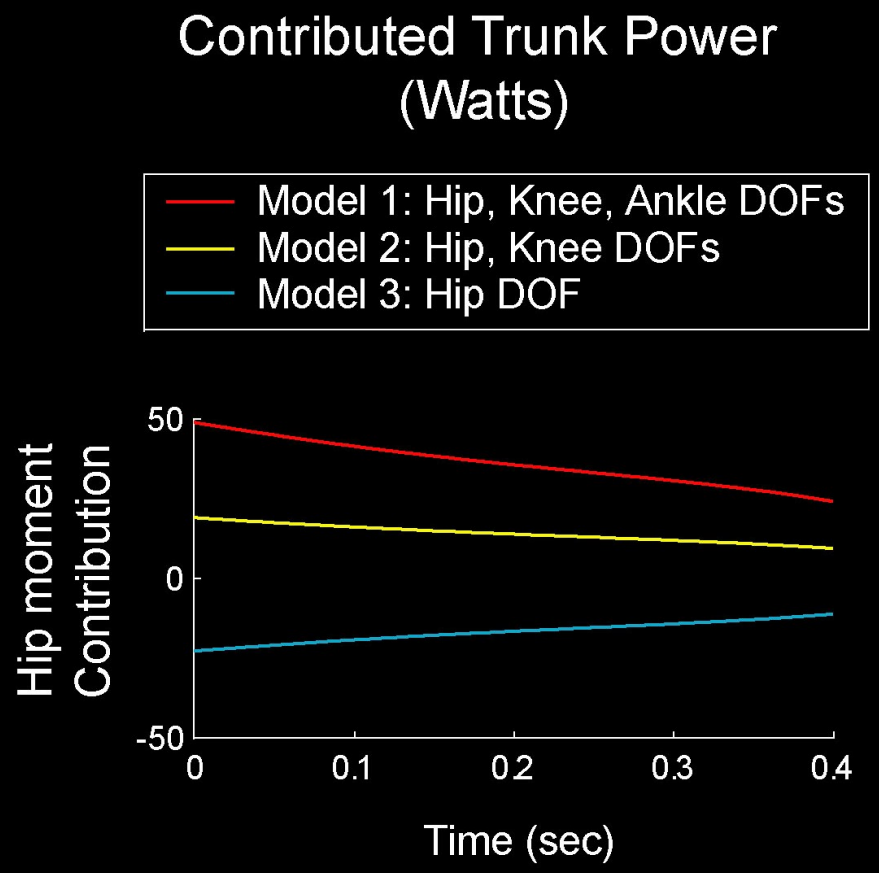
Horizontal GRF contributed by each moment/force differed between models

Example:



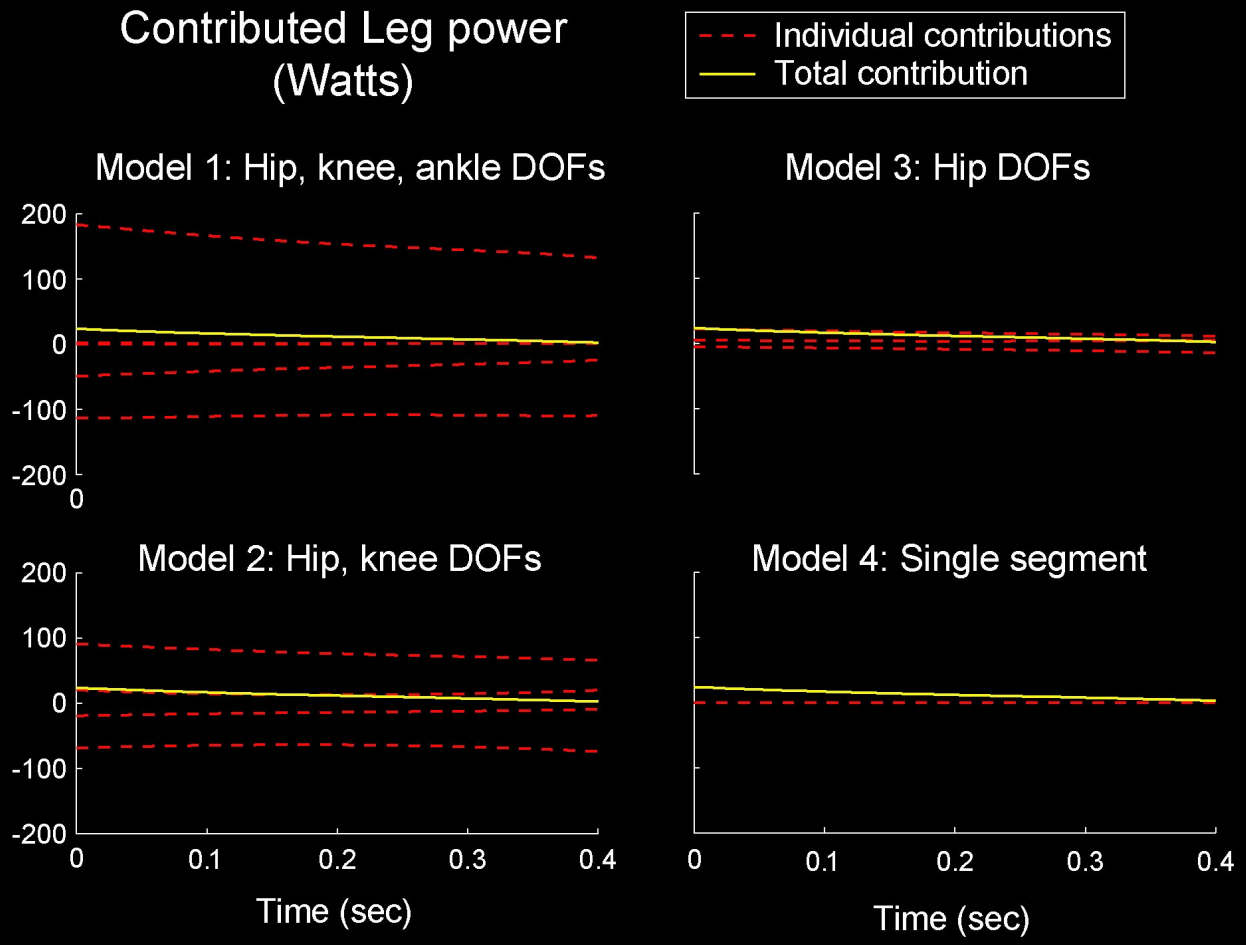
Trunk and leg powers contributed by each moment/force differed between models

Example:



Total contributions -> Identical for all models!

Example:



Discussion

IA contributions to the dynamics of a task are not physically well-defined

- Even though all models described simulated task dynamics, decomposition of GRF and powers differed between models
- Application of analysis in assessment of muscle and joint moment function during locomotion should be critically reevaluated

Remaining question: Contributions for any particular model meaningful?

- Ex., Do contributions represent moment's role in providing "support", "forward progression", etc.?
- Analyses suggests, maybe not.
  - Chen, 2005 (Gait & Posture, in press)
- Advantage of analyzing a simple task -> Results can be evaluated
- You have to understand the analysis, before it's applied to a complex task!

Thank you

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