4-21-2023

Sex-Based Biomechanical Models Impact Knee Joint Moments

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Abstract

Joint kinetic analysis is dependent on accurate link-segment models. Considering the current default model may not account for female segment anthropometry, we sought to develop and test sex-specific biomechanical models. We hypothesize that a sex-based biomechanical model would produce a significant alteration in hip, knee, and ankle joint moments compared to default model for females, but not males. Fourteen female and 18 male participants had hip, knee, and ankle joint moments quantified during running (4.0 m/s) using both a default and sex-based (both male and female) biomechanical model. Peak hip, knee and ankle joint moments were submitted to paired t-tests to compare the default and sex-based model measurements. Contrary to our hypothesis, both male and female sex-based models altered lower limb joint moments compared to the default model. Both the male and female sex-based model produced larger hip ($p < 0.011$; $p < 0.032$), but smaller ankle joint moments ($p < 0.023$; $p< 0.001$); while the sex-based knee joint moments were smaller for males ($p < 0.036$) and larger for females ($p < 0.049$). The current findings support the need for sex-based biomechanical models.

SEX-BASED BIOMECHANICAL MODELS IMPACT KNEE JOINT MOMENTS

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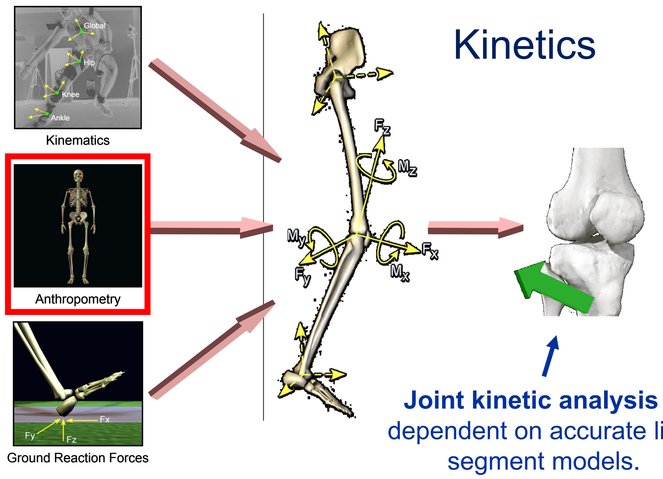
INTRODUCTION



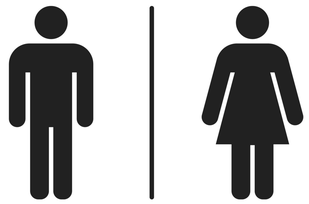
Joint kinetic analysis is dependent on accurate link-segment models.

But, current models **do not accurately account for female** segment anthropometry.

PURPOSE:
Develop and test impact of sex-based biomechanical model on knee joint kinetics.

METHODS

Participants:

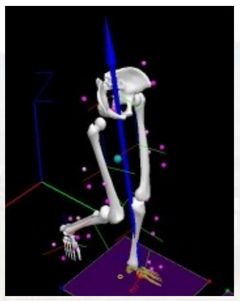


18 male **14 female**

Each participant had hip, knee and ankle joint moments quantified during a run (4.0 m/s) task.

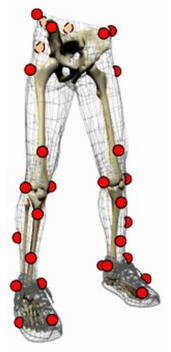
Biomechanical Analysis:

Synchronous 3D marker trajectories and GRF data were recorded with motion capture and processed in Visual3D to obtain knee joint kinetics.



METHODS CONT'D

Biomechanical Models:



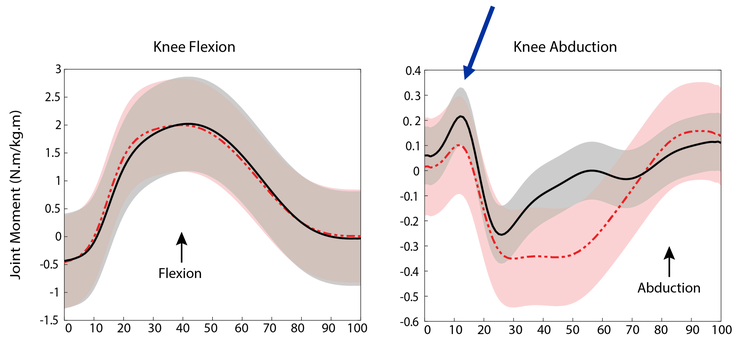
Lower limb models, each consisting of 7 segments and 24 DOFs, were created in Visual 3D.

Default model used segment properties as defined by Dempster (1959).

Sex-based models were built with segment properties (mass, MOI, CoM) defined by Dumas (2007).

Knee Joint Kinetics:

Maximum joint moment values across stance were recorded.



Minimum joint moment values across stance were recorded.

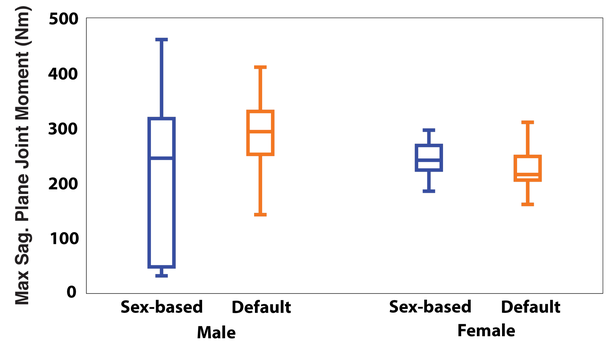
Statistical Analysis:

Default Model ⟷ paired *t-test* ⟷ **Sex-Based Model**

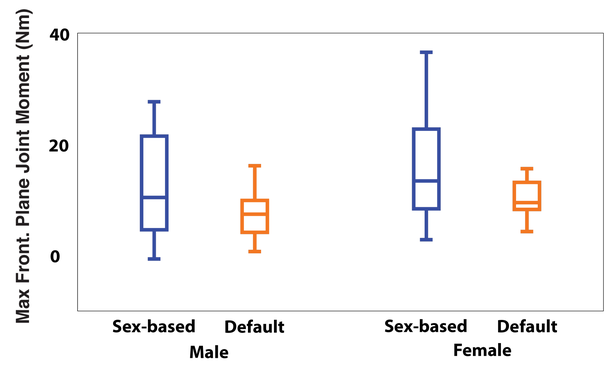
* α = 0.05

RESULTS

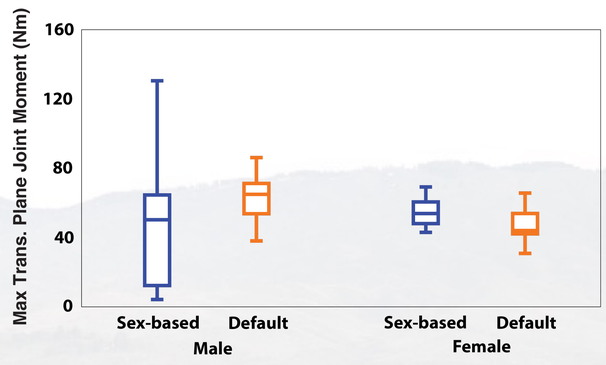
The sex-specific models lead to a **29% smaller male** (p = 0.036), but **11% larger female knee extension moment** (p < 0.001).



Interestingly, both the male and female models produced **larger knee abduction** (p = 0.015; p = 0.004) moments.



Male model **decreased the internal rotation moment 26**% (p = 0.039), while **female model increased it 17%** (p < 0.001).



KEY FINDING:
Current findings support the need for sex-based biomechanical models.