ABSTRACT FACE PAGE

1. **Presenting Author's name: __________Donald Hume____________**
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8. **Presenting Author's affiliation sector: (check one or more)**
   - X Academia
   - o Industry
   - o Federal Employee/Contractor
   - o Private Foundation
   - o Other: __________________
9. **Presenting Author's Career stage: (check one)**
   - o K-12 student
   - o Undergraduate student
   - o Graduate Student
   - X Post-doctoral Trainee
   - o Young employee (within first 3 year of post-training position)
   - o Mid-level employee (3-10 years of post-training position)
   - o Senior-level employee (10+ years of post-training position)
   - o Other: ____________________________
10. **Website / twitter handle / other public links (optional): ___________________**
11. **Is this the research presented in this abstract supported by IMAG MSM-related U01 funding? Yes**
12. **If the Presenting Author is a trainee, who is the trainee's primary research advisor? _Kevin Shelburne______**

TRAINEE POSTER AND ORAL PRESENTATION COMPETITONS:

New to the meeting this year, we are holding *both* a trainee poster competition and a trainee oral presentation competition! If the presenting author is a trainee (i.e., a student at any level or a post doctoral trainee), he/she may enter his/her abstract in the trainee poster competition, the trainee oral presentation competition, or both competitions. Trainees may also submit more than one abstract to the meeting and enter more than one abstract in these competitions. Prizes will be given to the presenters of the top-ranked trainee oral presentation and the top-ranked trainee poster (judged during the meeting by the Program Committee).

13. **If the Presenting author is a trainee, would the Presenting Author like to enter his/her abstract in the Trainee Poster Competition*? Yes**

*Note: Trainees who enter the poster competition are expected to stand by their poster during the scheduled poster sessions and present them to the judges.

14. **If the Presenting author is a trainee, would the Presenting Author like to enter his/her abstract in the Trainee Oral Presentation Competition**? No**

**Note: The Program Committee will select the top four abstracts from trainees who elect to enter their abstract into the trainee oral presentation competition, these four trainees will be notified by Feb. 17th, and they will deliver their oral presentations (which will be judged) on the second day of the meeting after lunch.

FRAMEWORK FOR BUILDING FINITE ELEMENT MUSCULOSKELETAL SIMULATIONS DIRECTLY FROM MOTION DATA

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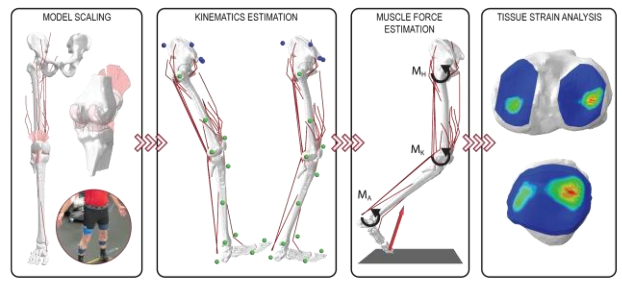
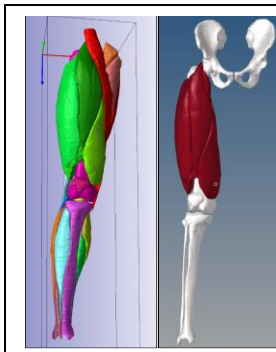
BACKGROUND: Diseases and injuries often affect tissues at the microstructural scale and small-scale pathology impacts biomechanics at larger scales, leading to whole-body movement compensations and oftentimes further injury or degeneration. Ultimately, a multiscale approach, describing the behavior of individual tissues, and the biomechanics of the whole body, is needed to elucidate the etiology of diseases, mechanisms of adaptation, and best treatments. **The overall goal is to create a comprehensive multiscale musculoskeletal model of the human lower extremity**, which includes the seamless connection between tissue and whole-body dynamic function and enables realistic investigations of musculoskeletal disease and treatment. Our efforts are grounded by *in vivo* and *in vitro* data to support model development, and our participation in Reproducibility in Simulation-Based Prediction of Natural Knee Mechanics (R01EB024573, Erdemir PI). Recent advances in computational efficiency and control schemes for muscle force prediction have made the use of sophisticated musculoskeletal finite element (MSFE) models more practical. Yet, the formulation of subject-specific MSFE simulations remains a challenging problem.

METHODS: We developed a user-friendly software, *ReadySim*, to build and run simulations that (1) scale the size of a template MSFE model and efficiently estimate (2) joint kinematics and (3) muscle forces from human motion data collected in a typical gait laboratory. The software uses laboratory marker data to scale model segment lengths and estimate joint kinematics. Concurrent muscle force and tissue strain estimations are performed based on the estimated kinematics and ground reaction forces. Both software and template model are made freely available on SimTK on the *ReadySim* project page.



ReadySim is a software for preparing subject specific finite element models for use in simulations of activity.

RESULTS: *ReadySim* was used to linearly scale the size of the multi-scale MSFE model to match marker data obtained in the lab. Pelvis, femur, tibia, and foot were scaled in the ML (SF=1.09), SI (SF=0.97), SI (SF=0.96), and AP (SF=1.14) axes, respectively. Joint kinematics were estimated for the stance phase of gait and chair rising, with RMSE between model markers and experimental markers falling between 3.5 mm and 11 mm. Concurrent muscle force and tissue strain estimation were performed using the prescribed kinematics with resulting joint contact forces falling within bounds reported for patients with instrument knee implants. *ReadySim* software managed parallel process control while performing kinematics and muscle force estimation on 13 time points concurrently for gait and chair rising, requiring 100 hours of computational time.



Reconstructions of the Visible Human Male and Female (left) are being created and shared for development of 3D muscles (right).

CONCLUSIONS: *ReadySim* provides a platform for researchers to perform multi-scale musculoskeletal simulations from data collected in the motion laboratory. However, muscle requires a deformable 3D volumetric representation to understand the feedback interaction between muscle force and motion. As the limb moves, the muscle deforms, changing the pathways of the muscle fibers and their moment arms, which alters the force generated to achieve a movement. Furthermore, deep flexion at the hip and knee can exacerbate impingement of the implanted hip and drive performance uncertainty in the implanted knee through abdomen-thigh and thigh-calf contact, respectively. To this end, musculoskeletal geometries of the lower-extremity muscles are being extracted from the Visible Human Male and Female and used to inform 3D visco-hyperelastic muscle modeling with fiber directionality determined through anatomically informed CFD simulations. Furthermore, we have developed a device to measure *in vivo* knee laxity which when coupled with high-speed stereo radiography will improve the subject specificity of the next generation of high-fidelity subject-specific neuromusculoskeletal simulations.