

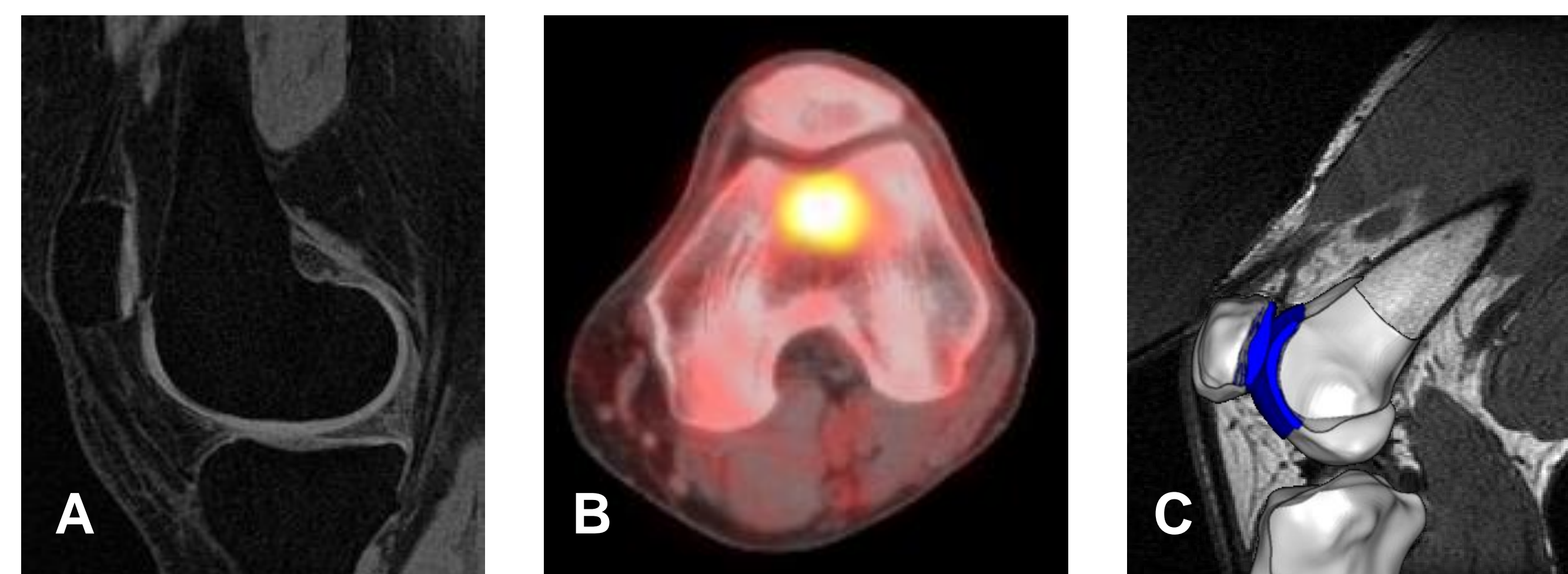
# A Multiscale Modeling Framework for Predicting Bone and Cartilage Stress in Patients with Patellofemoral Pain Syndrome

Pal, S<sup>1</sup>; Besier, TF<sup>2</sup>; Draper, CE<sup>1</sup>; Gold, GE<sup>1</sup>; Fredericson, M<sup>1</sup>; Delp, SL<sup>1</sup>; and Beaupré, GS<sup>1,3</sup>

<sup>1</sup>Stanford University, CA; <sup>2</sup>University of Auckland, NZ; <sup>3</sup>VA Rehab. R&D Center Palo Alto, CA

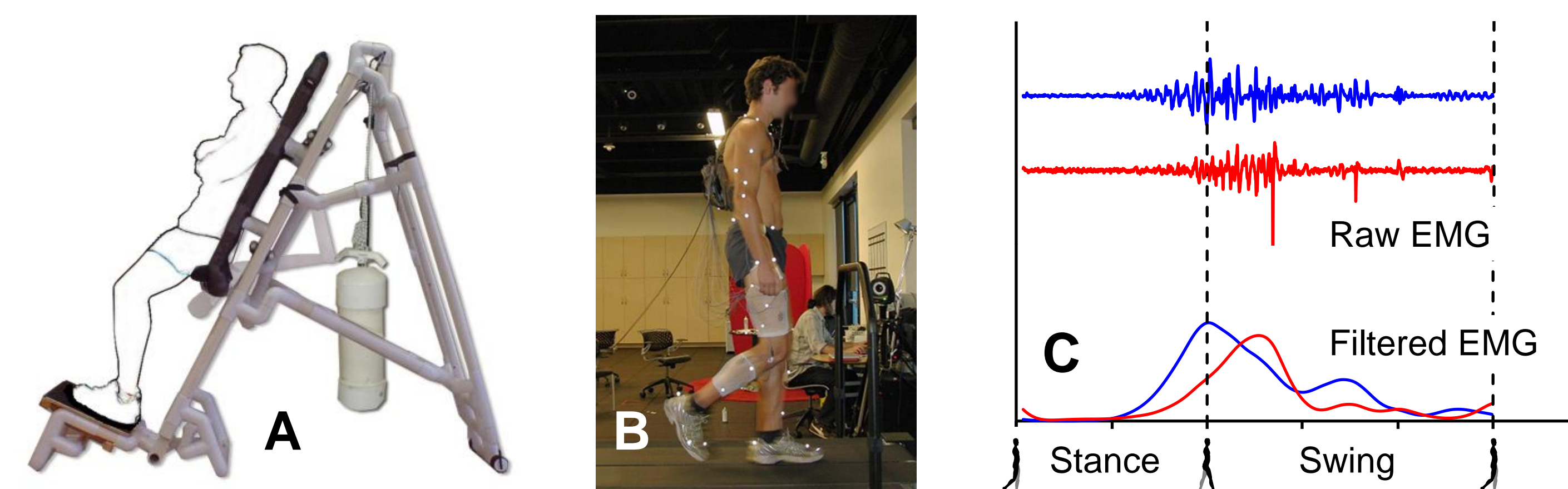
**Purpose:** To determine patellofemoral (PF) joint stress during activities of daily living using patient-specific computational modeling.

## Imaging



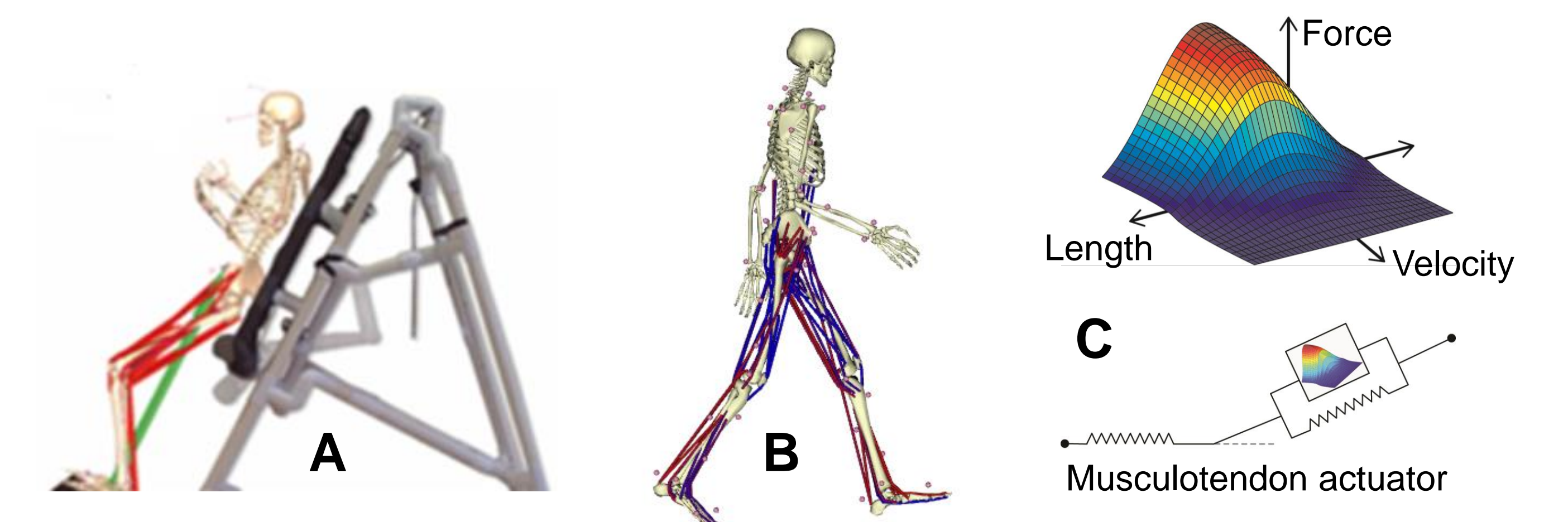
We acquired 3D knee geometry of subjects using a combination of (A) supine, high resolution MRI and (B) PET/CT imaging. We acquired *in vivo* kinematics by registering the models to upright, weightbearing MRI (C). The hotspot on the PET/CT image indicates region of elevated bone metabolic activity.

## Motion Analysis



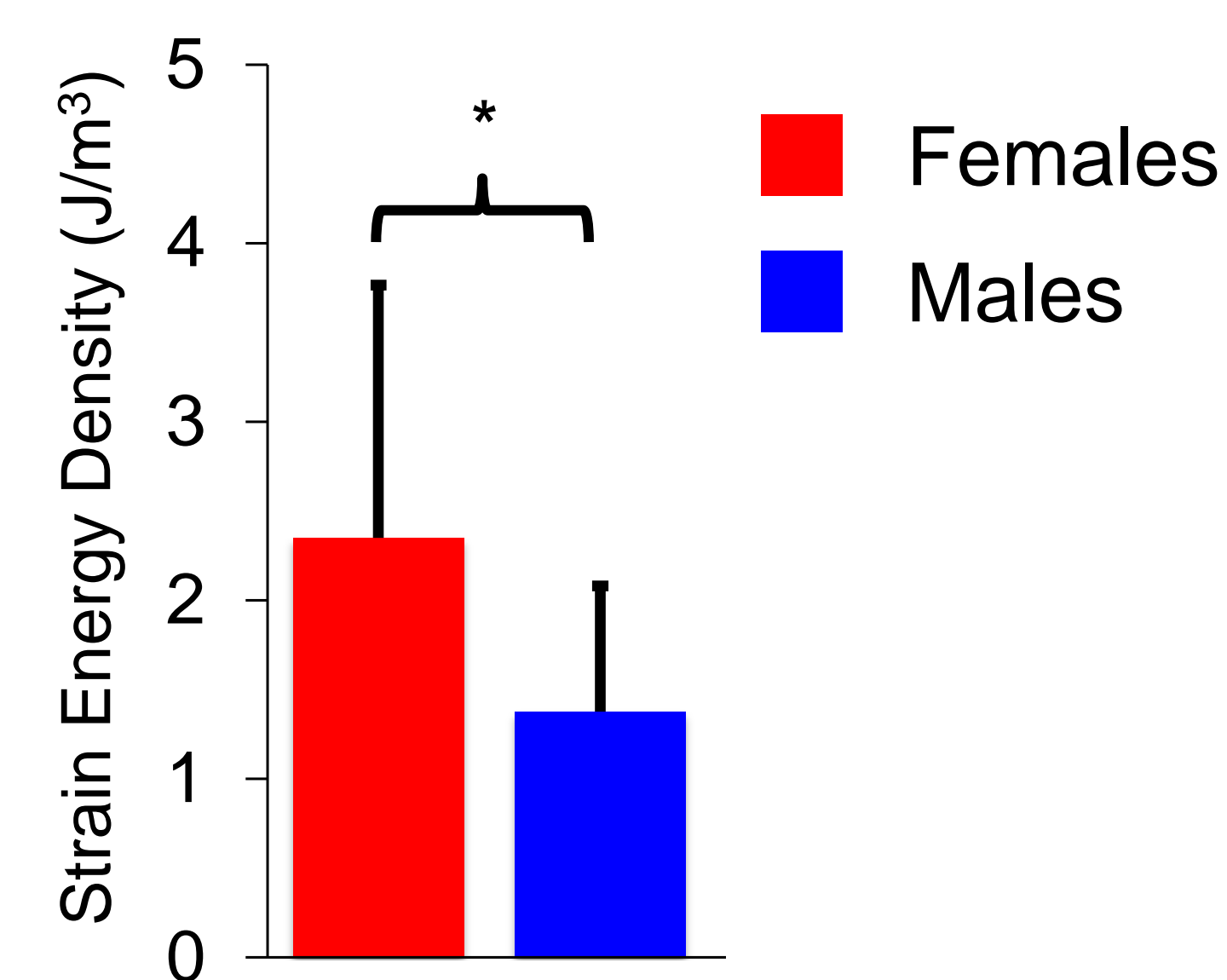
We analyzed the motion of subjects while performing activities of daily living, including (A) upright, weightbearing squat and (B) walking. We recorded electromyography (EMG) from lower limb muscles during the functional tasks (C).

## Whole Body Simulations



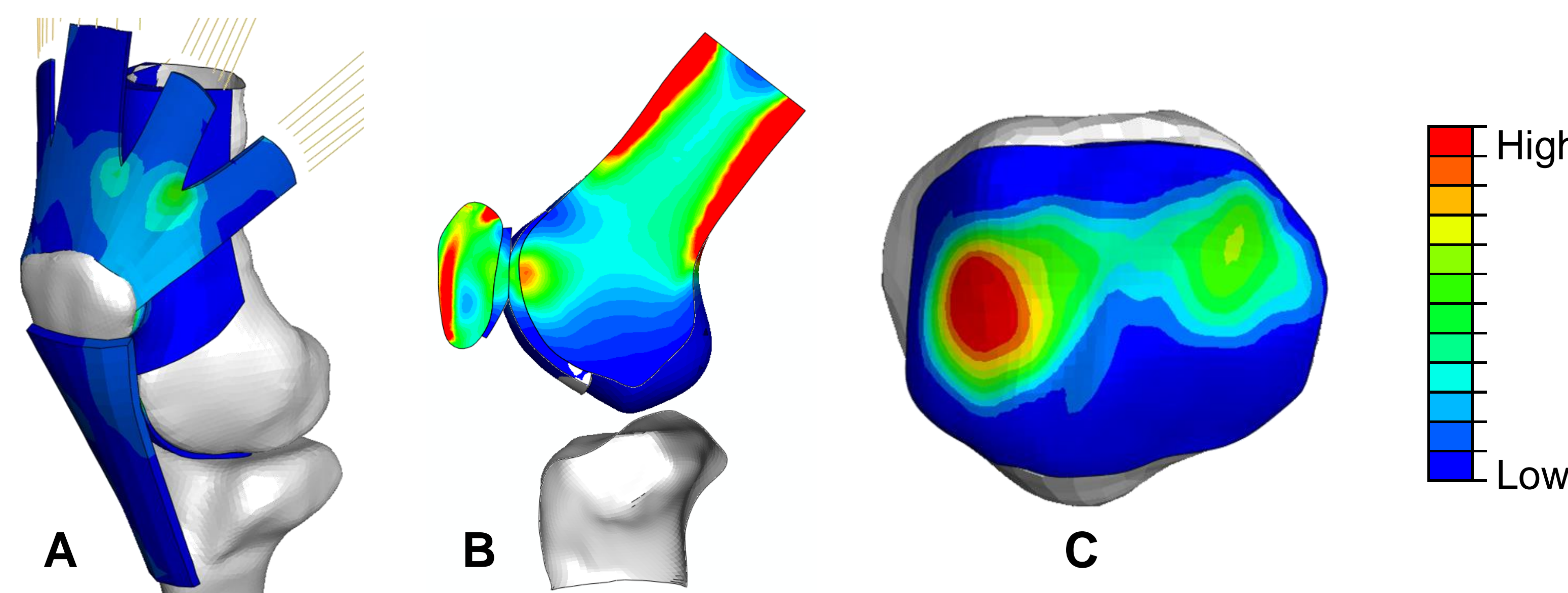
We created subject-specific simulations of activities of daily living (A, B) using an EMG-driven musculoskeletal model (C). The musculoskeletal model included a Hill-type muscle actuator and EMG-to-activation dynamics.

## Results: Gender Differences



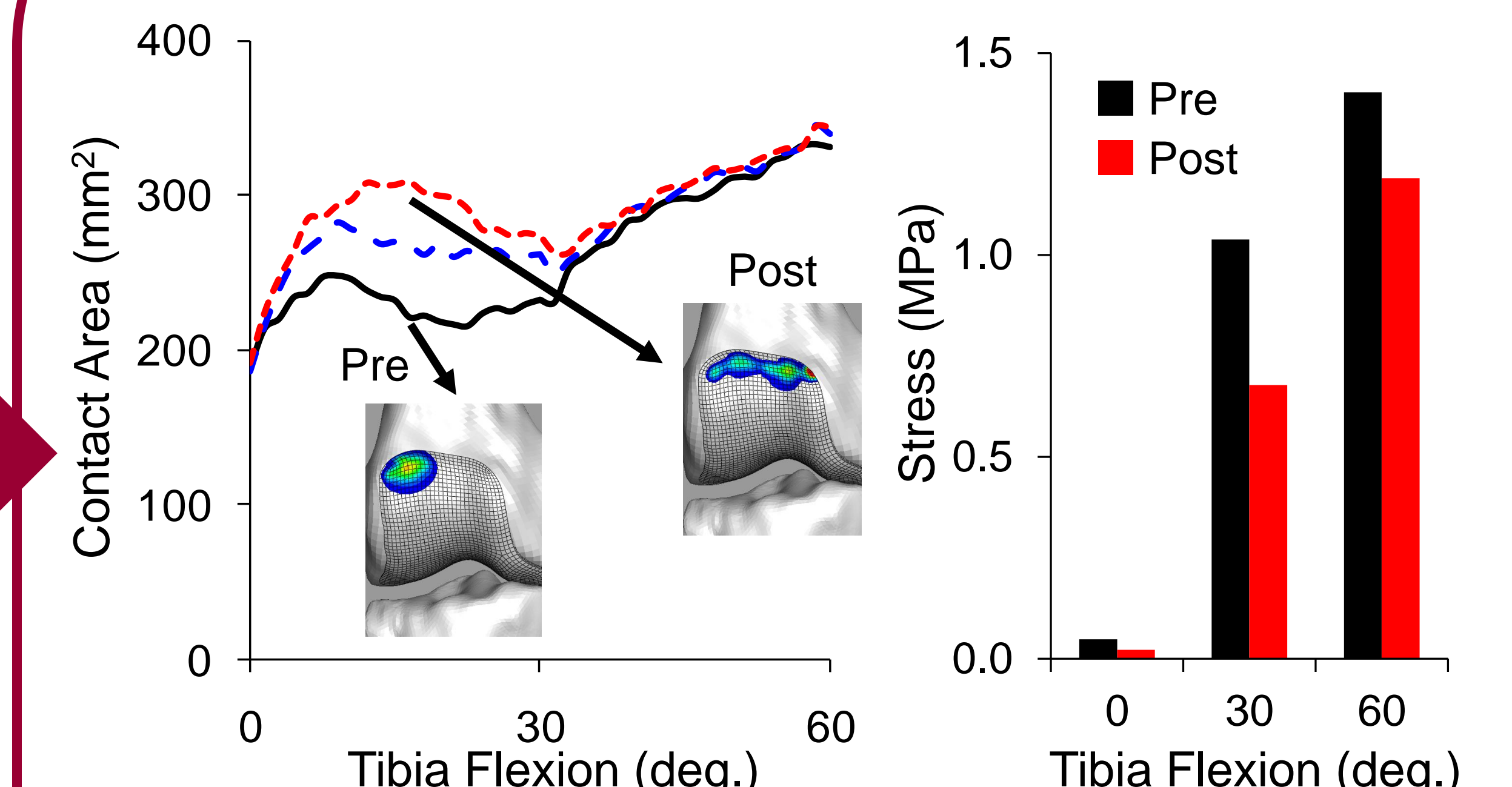
Females with PF pain had greater patellar cartilage stress than males with PF pain ( $p = 0.02$ ). This may explain the greater prevalence of PF pain in females compared to males.

## PF Joint Simulations



We developed patient-specific finite element models of the PF joint (A). We determined bone and cartilage stress during activities of daily living (B, C). We assigned cartilage material properties based on experimental studies, and bone material properties based on PET/CT data.

## Results: Predict Clinical Outcomes



A vastus medialis muscle strengthening intervention resulted in increased contact area and decreased PF stress. This is a personalized medicine approach to treat PF pain.

**Public health relevance:** Patellofemoral pain syndrome is common, affecting millions of individuals nationwide and costing billions in health care spending. Current treatment methods are unpredictable and often unsatisfactory as this syndrome has many possible causes that are difficult to diagnose. The goal of our study is to understand the mechanisms underlying PF pain and improve the efficacy of clinical outcomes.



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