Estimation of Knee Cartilage Pressures During Cycling

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Introduction

Anterior knee pain is the primary reason cyclists seek medical care; pressure at the patellofemoral joint is believed to be a primary contributor. Current musculoskeletal models use 1 degree of freedom (DOF) patellofemoral joints that limit our understanding of important patellofemoral biomechanics.

The purpose of this work was to update and test an existing 12 DOF knee model for use with cycling.

Methods

We used biomechanical data of a single subject (Male, 27yrs, 1.82m, 77.3kg) cycling at 216 Watts and 90RPM while synchronous motion and force data were collected [1].

The model was implemented in an extended version of OpenSim (shorturl.at/bfFK1). During deep knee and hip flexion the scaled model's quadriceps penetrated their wrap surfaces. To fix the wrapping, the wrapping surfaces and the patellar attachment locations of the quadriceps muscles were updated.

Code for scaling and updating the model, running the simulation, and presenting the results are available (shorturl.at/jkOZ5). A version of the abstract with figures is also included.

Results

The simulation enabled visualization of knee cartilage pressures over the whole revolution (**Figure 1**). Separation of tibiofemoral forces into medial and lateral surfaces showed that the first peak (25% of revolution) occurred primarily on the lateral plateau, while the second peak (50% of revolution) occurred primarily on the medial plateau (**Figure 2**). Cartilage pressures show that the patella is only being compressed during the first 25% of the revolution, and primarily on the lateral facet (**Figure 3**).

Discussion

The simulation provides novel information about knee biomechanics during cycling. Follow-up research will leverage this model to investigate the effects of anatomic (inherent) and kinematic (modifiable) factors on patellofemoral cartilage pressures during cycling.

[1] Gatti et al. Journal of Science and Medicine in Sport, 2020
[2] Lenhart et al. Annals of Biomedical Engineering, 2015

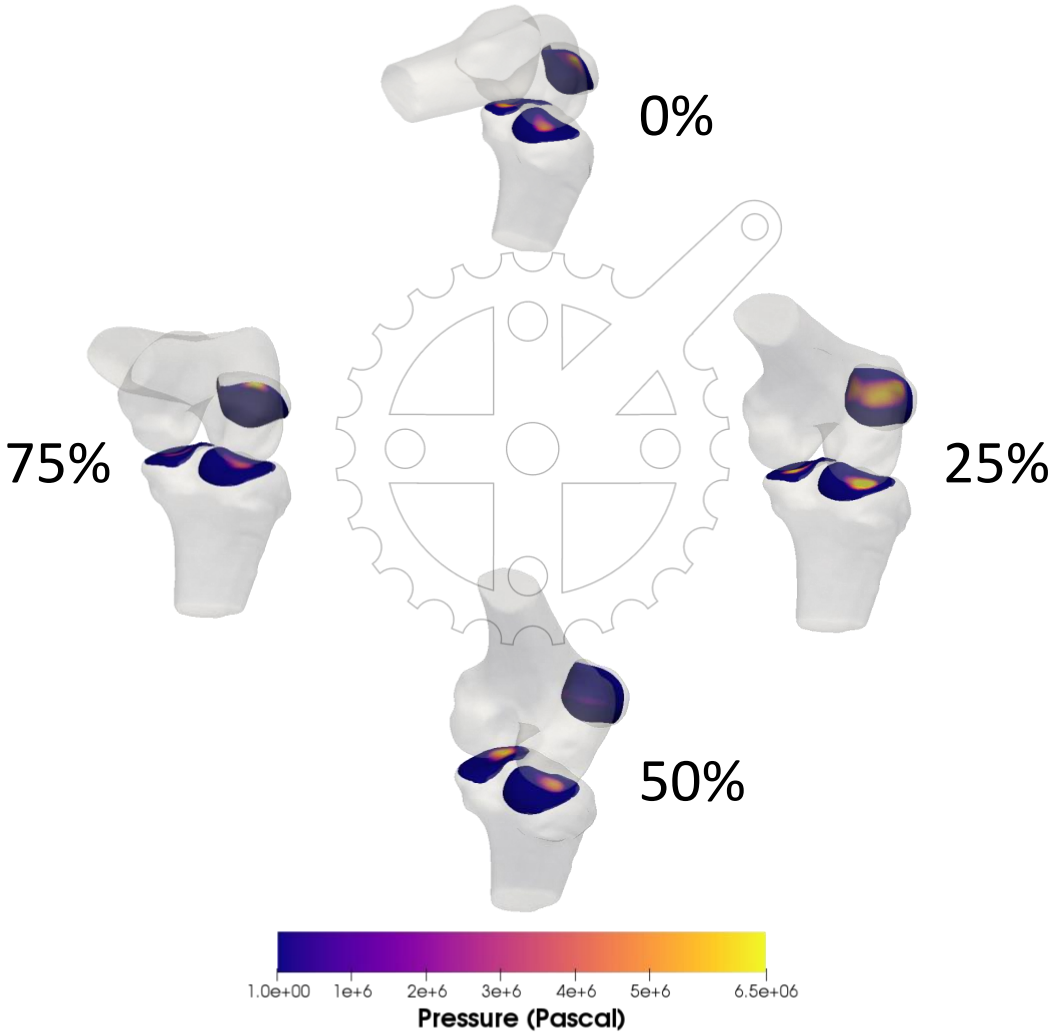

Figure 1. Cartilage surface pressures of the patella and tibia at 25% increments throughout a pedal revolution. The highest tibial pressures can be seen at 25% and 50% of the revolution, while only the 25% time point has meaningful patellar pressures.

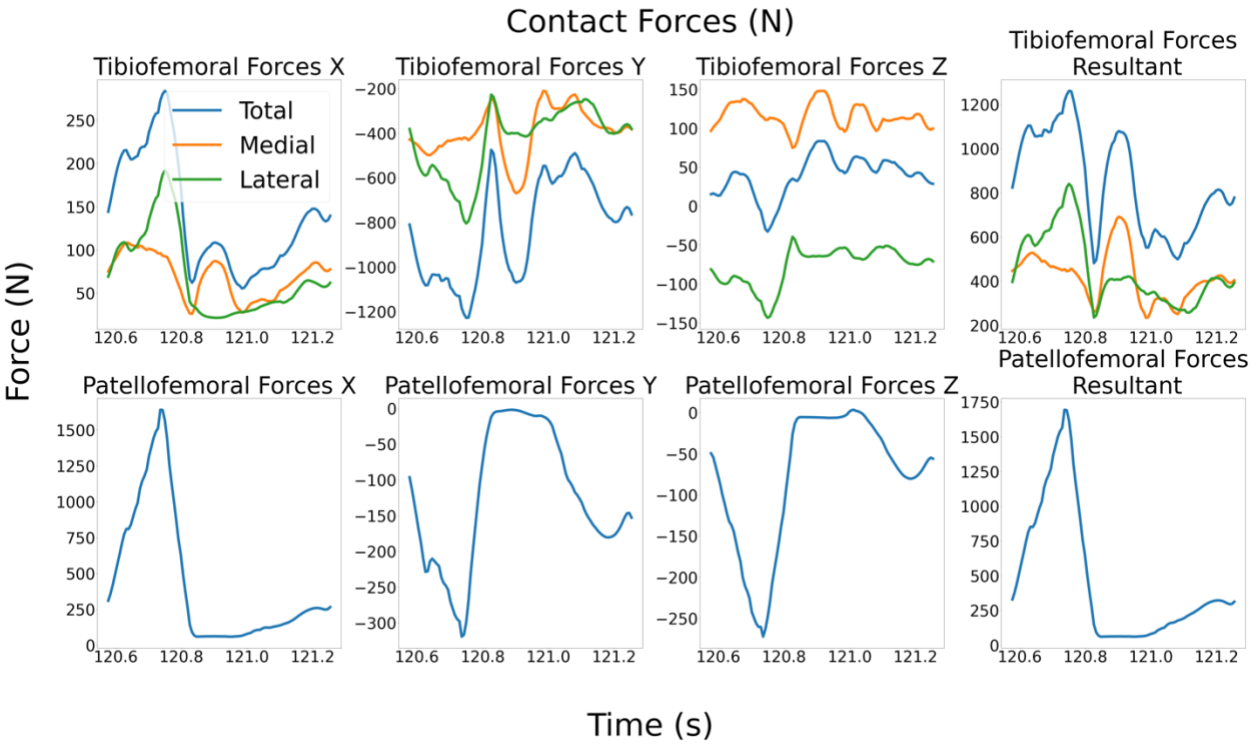

Figure 2. Tibiofemoral and patellofemoral forces over one complete pedal revolution. Time starts at the top of the revolution (12 o'clock) and ends when the pedal returns back to the start.

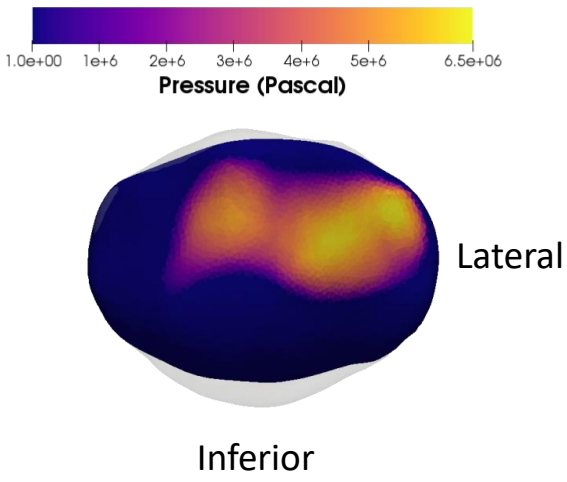

Figure 3. Visualization of the patellar cartilage surface pressures at the time of the peak resultant patellofemoral force (24% of the revolution). The pressures are primarily occurring on the lateral and top half of the patella matching what is expected based on arthrokinematics of the patella.