ENGINEERING

Quantifying Changes in Muscle Force in the Presence of Fatigue

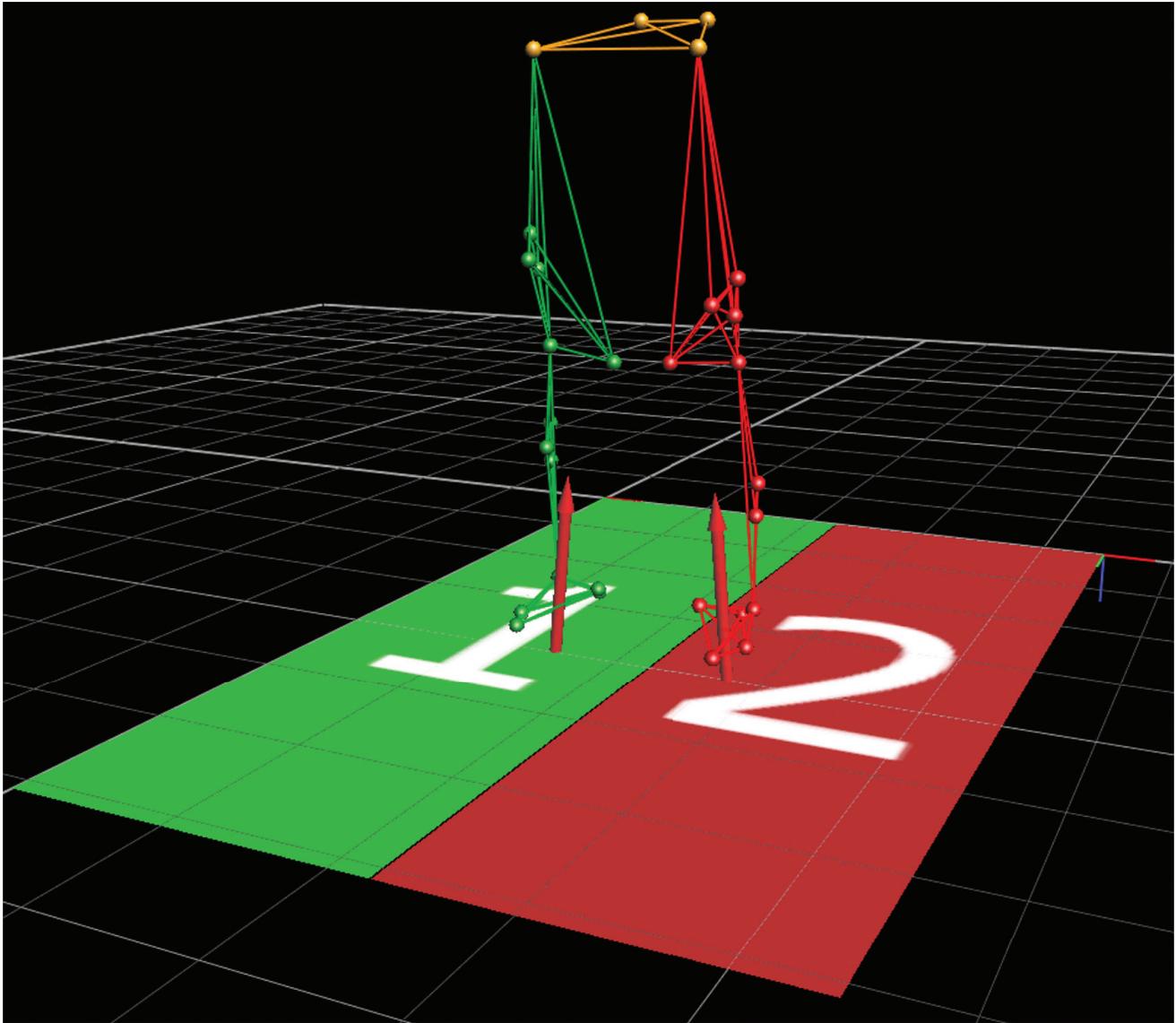**Student researcher: Emily Bywater, Junior**

When athletes exert their bodies to their physical limits, their risk of injury is increased due to fatigue. A better understanding of muscle and joint contact forces leads to more effective injury prevention techniques.

Previous studies have analyzed fatigue using inverse dynamics or indicators of pulmonary and respiratory function. With a biomechanics research group, I am quantifying fatigue in runners through pre-run and post-run comparisons of muscle-specific constants calculated from a constitutive law derived from dimensional analysis. This law relates exerted muscle force to measurable parameters, including voltage from electromyography (EMG) readings. The constants within the law define proper scaling factors for individual muscle forces. Reflective markers and EMG sensors will be attached to experienced runners as they perform a 2-mile run at a 7% reduction from race pace. This run will be done on a treadmill surrounded by a motion capture system to collect ground reaction forces, muscle activity, and kinematic data. I will create individualized fatigue models comparing pre-run and post-run muscle function, performance differences by gender, and fluctuations in muscle force during training. It is hypothesized that muscle forces will decrease with fatigue as energy is depleted and injury risk increases. The constants are directly proportional in the equation, but their response to fatigue effects is unknown.

Quantified muscle constants and forces may be used with tissue mechanics to prevent injuries in athletes by helping these athletes train and recover more effectively. This study is an important step in optimizing training by quantifying the limits of individual athletes.

Research advisor Eric Nauman writes: "Emily's work is bringing together physiology, engineering, and computing, and provides a foundation for us to reduce the frequency of injuries in athletes and soldiers. Understanding how muscles fatigue may even help us design smart prosthetics and patient-specific implants."

Bywater, E. (2020). Quantifying changes in muscle force in the presence of fatigue. *Journal of Purdue Undergraduate Research, 10,* 89–91.

Depicted here is a reconstruction of the lower body in a static position on a treadmill with two built-in force plates. The computer-generated reconstruction is based on reflective markers (pictured as spheres) that are picked up by motion tracking cameras. Measured ground reaction forces are seen here as arrows.

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