Stepping up our understanding of human foot biomechanics with computer modelling and simulation

Supervisory team:
Main supervisor: Prof Dominic Farris (University of Exeter)
Second supervisor: Dr Xijin Hua (University of Exeter)
Dr Matthew Ellison (University of Exeter)

Host institution: University of Exeter (St Luke's)

Project description:
As humans, our feet have evolved to be our main point of contact with the ground when moving around. As such, the shape, size, and strength of the foot's bones and muscles reflect the need to bear our weight and push us from step-to-step. Key features include the arrangement of bones into load-bearing arches, and strong-elastic tendons to add a spring in our step. Recent experimental research suggests an important role for muscles within healthy feet, contributing to its versatile mechanical capabilities. However, the musculoskeletal complexity of our feet makes it challenging to quantify and pick apart the contributions of individual muscles, tendons and bones to the foot's overall mechanical behaviour. This project aims to more deeply understand the evolution of the human foot by quantifying and evaluating the individual contributions of foot muscles to walking and running mechanics.

Measuring individual muscle forces is not feasible in live people, and therefore the project will combine experimental measurements with computer modelling and simulation methods to achieve the above aim. This approach draws on the supervisory team's interdisciplinary expertise in physiology, biomechanics, and engineering disciplines. Prior work within the main research group provides experimental data and baseline models required for initial project development. The student will receive training in appropriate experimental procedures and collect further data including: gait analysis, motion capture, electromyography, and MRI. State-of-the-art equipment, facilities, and expertise for this will be available to the student at the University of Exeter. Training and supervision will also be provided for modelling and simulation work using the open source and internationally recognised software OpenSim to generate simulations of foot muscle forces. It is also planned to include training in finite element modelling methods to simulate foot bone stresses. On completion of the PhD, the student is anticipated to have developed an interdisciplinary cutting-edge skill set for researching musculoskeletal biomechanics and have generated valuable resources and publications that significantly advance this field of research. The detailed understanding of foot biomechanics, form, and function generated will further our fundamental understanding of human musculoskeletal evolution by providing new insight into one of its key markers – our feet. Combined with the methods developed, it also sets a platform for more applied research into foot dysfunction associated with ageing, disease, and musculoskeletal injury.

Our aim as the SWBio DTP is to support students from a range of backgrounds and circumstances. Where needed, we will work with you to take into consideration reasonable project adaptations (for example to support caring responsibilities, disabilities, other significant personal circumstances) as well as flexible working and part-time study requests, to enable greater access to a PhD. All our supervisors support us with this aim, so please feel comfortable in discussing further with the listed PhD project supervisor to see what is feasible.