A GEOMETRICALLY CONSISTENT MUSCULOSKELETAL MODEL OF THE LOWER EXTREMITY

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Introduction

Subject-specific musculoskeletal models are essential to achieve reliable muscle and joint force predictions for individual patients. The aim of this study is to develop a geometrically consistent template model or atlas, which is easily scalable to obtain a subject-specific model using morphing techniques based on medical imaging data. This atlas contains both imaging data (CT and MRI), segmented bones and muscle volumes, coordinates of muscle attachment sites and via points.

Methods

Both a CT and an MRI scan were made of a fresh and unfrozen cadaver. From the CT, bones of the lower extremity were segmented into STL-files and the MRI was used to segment all muscles of the right leg into STL-files. Both were segmented using Mimics 15.01 (Materialise NV, Leuven, Belgium).

A complete dissection was performed, in which the contour of the muscle attachments sites, mass and volume of all muscles, moment arms of several bi-articular muscles, wrapping surfaces and joint centers and axes were measured. All points were measured using the Brainlab Kolibri™ image-guided surgery platform.

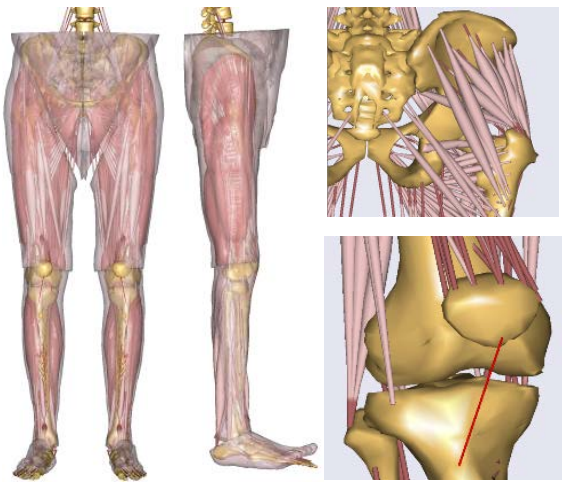

Figure 1: Segmented muscle and skin (left and mid) and close-up of hip and knee region (right)

Based on the cadaver measurements, a new geometrically consistent musculoskeletal model was implemented in the AnyBody Modeling System (5.3.0, AnyBody Technology) (Fig. 1). The modelled leg consists of 55 muscle-tendon parts described by 166 elements.

An inverse-dynamic simulation was performed of a single gait trial of a single healthy subject using a simple anthropometrically scaled model and a subject-specific model, by morphing the atlas to the subject.

Results

The activity levels of the anthropometrically scaled model and subject-specific model differed substantially (Fig. 2). For the Gastrocnemius Lateralis, the activity dropped below 1 using a subject-specific model.

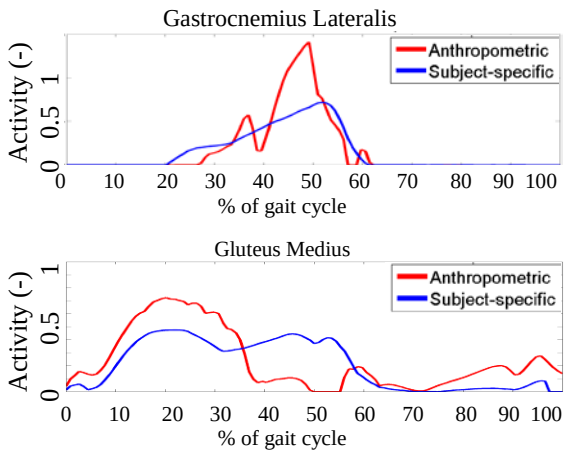

Figure 2: Activity levels during walking.

Discussion

Preliminary results suggest that subject-specific geometry is required for accurate predictions of muscle and joint forces. Furthermore, the developed atlas can be used to create subject-specific models in a quick and accurate way.

Acknowledgement

The TLEM*safe* project is funded by the European Commission FP7 Programme.