

The variable relationship between sarcomere number and fascicle length when measured in vivo in human lower limb muscle

G. Lichtwark¹, D. Farris¹, X. Chen², P. Hodges¹, G. Sanchez³, S. Delp²

¹ The University of Queensland, Australia. ² Stanford University, USA. ³ Zebra Medical Technologies, USA

Introduction: Sarcomeres are the building blocks of muscle fibres. Adding more sarcomeres along the length of fibres (sarcomerogenesis) is thought to be an important adaptation to stretching and eccentric muscle exercise that can reduce muscle fibre strain and potential damage. However most of our knowledge of these processes has come from studies of animal muscle, where sarcomere number can be obtained from excised muscle. Indirect in vivo measures of muscle fascicle length, typically made with ultrasound imaging, have been used as a proxy making an assumption that passive muscle fascicle length is directly related to sarcomere number. However, this assumption has not been directly tested in human muscle, in vivo. The aim of this study was to assess the relationship between sarcomere number and fascicle length when measured from the same region of muscle at three different muscle lengths and also two different regions of muscle at the same muscle length.

Methods: We used a novel microendoscopy technique, which acts like a microscope embedded in a needle, to directly measure sarcomere length in the human tibialis anterior muscle. We also used B-mode ultrasound imaging to examine fascicle length in the same region of muscle and divided fascicle length by sarcomere length to estimate sarcomere number. Ankle angle was changed to alter overall muscle length. The needle was removed and re-inserted at a distal location to measure sarcomere length in the distal part of the muscle, with the ankle in a common neutral angle.

Results: The average sarcomere number was found to be similar across three different muscle lengths when measured from the same region of muscle. While there was a significant linear relationship between the strain of the sarcomeres and strain of the fascicles ($R^2 = 0.32$, $P < 0.01$), there was a large intra- and interparticipant variation in sarcomere lengths. Sarcomere length was found to be longer in the distal region of the tibialis anterior muscle ($P < 0.05$), despite the fascicle lengths being similar. As such there was a decreased sarcomere number ($P < 0.05$) in fibres within the distal region of the muscle.

Discussion: The results suggest that it may be hard to predict sarcomere numbers from passive lengths of muscle fascicles. The difference in the sarcomere number of fibres in different regions of muscle maybe related to region specific strains that the fibres experience during every day contractions. The microendoscopy method is likely to be an important new method to investigate muscle adaptation to exercise.