World Congress of Biomechanics 2018 Abstract

Title

Investigating the biomechanical and physiological effects of simulated prosthetic loading on healthy lower limb tissues

Introduction

The soft tissues in an amputated residual limb form a critical interface with a prosthesis, transferring load during activities of daily living. This inevitably creates pressure and shear forces at the skin-device interface, which can result in recurring skin and soft tissue breakdown[1]. There are critical relationships between tissue injury and the magnitude and duration of interface pressure and tissue strain[2], where critical vascular and lymphatic vessels can collapse under load. The aim of this study was to develop a human *in-vivo* protocol for assessing the biomechanical and physiological response of lower limb soft tissues to loads representing prosthesis use.

Methods

Pressure was applied to the calf of non-amputees using a sphygmamometer mimicking a total surface bearing prosthesis, with indenters representative of socket rectification. The cuff was inflated from 20 mmHg with 10 mmHg increments every 10 minutes until an ischaemic response was observed. During these increments of inflation an array of measurements was taken at sites relevant to prosthetic load bearing, to assess biomechanical response and characterise tissue injury risk[3]:

- T1 MR Imaging to characterise direct tissue deformation;

- Transcutaneous oxygen tension (T_cPO_2) and carbon dioxide tensions (T_cPCO_2) using a skin mounted sensor (TCM4, Radiometer, Denmark) and categorised according to three ischemia levels;

- Interface pressure corresponding to applied cuff pressure (Oxford Pressure Monitor II, Talley, UK).

Results

Preliminary data are presented for one male participant aged 34yrs. A typical indenter generated gross compressive strain across the anterior and lateral muscle compartments of ≈28% (Fig1A,B). Interface pressures ranging from 8-240 mmHg corresponded to cuff pressures of 0-40 mmHg. Decreased T_cPO_2 and increased T_cPCO_2 were indicative of an ischaemic tissue response at 30 and 40 mmHg cuff pressure (Fig1C).

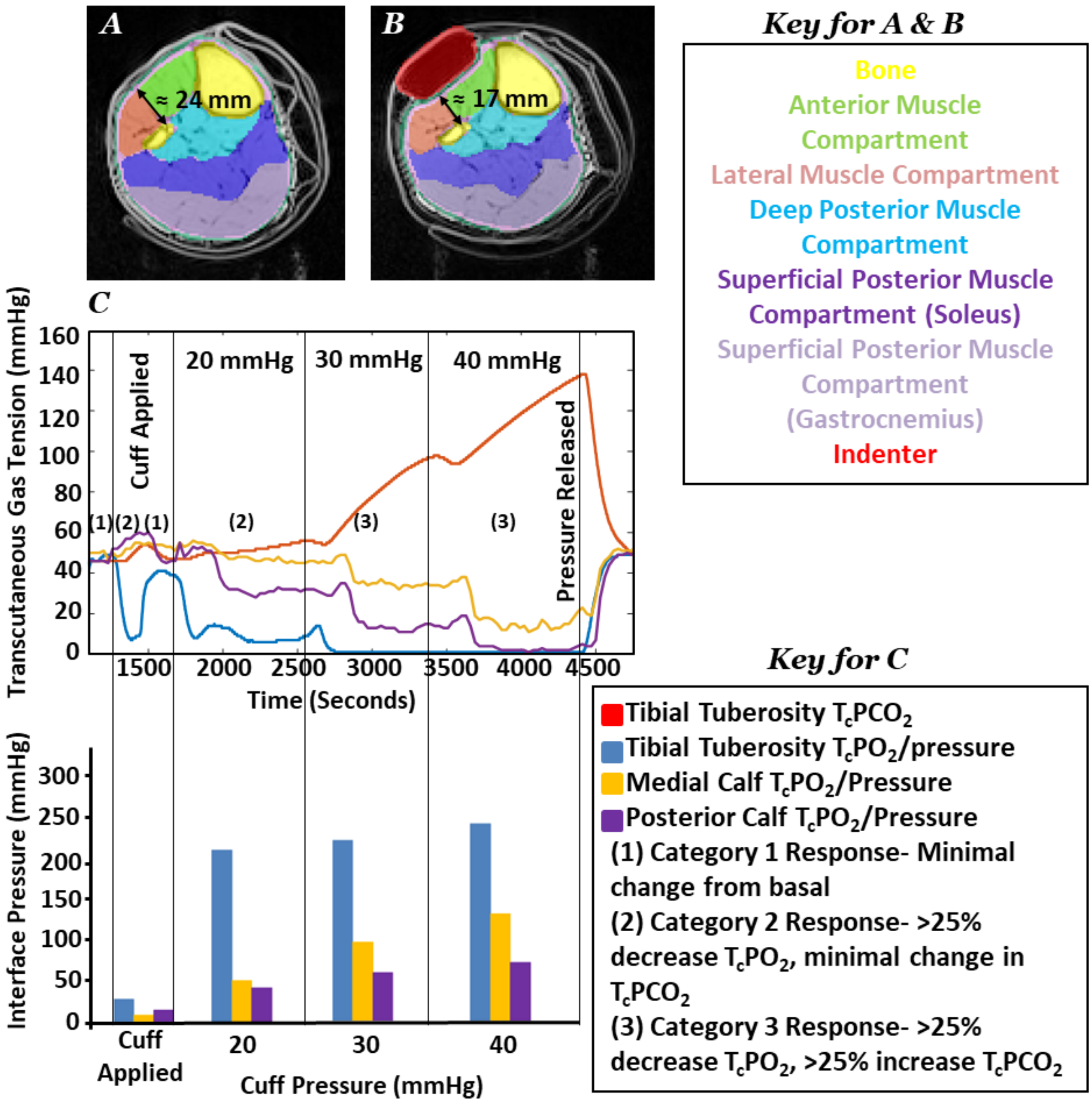

Figure 1 Transverse section MR images displaying calf at (A) baseline and (B) loaded with 60 mmHg cuff pressure plus an indenter at the tibialis anterior. (C) Transcutaneous Gas Tension results under increasing cuff pressure with corresponding interface pressure and ischaemia category

Discussion

This study has provided a methodology to apply representative loads on lower limb soft tissues to simulate prosthetic use. The pressure measured at the cuff interface varied between limb sites, peaking at 240 mmHg over indenter sites. This resulted in an ischemic response of the loaded skin tissues, represented by a decrease in T_cPO_2 and an increase in T_cPCO_2, and representing a precursor to tissue injury. Tissue deformations of >25% were observed over indenter sites using MRI, revealing both superficial and deep soft tissue structure effects. This array of measurement techniques will be translated for prosthesis users, to enhance knowledge of biomechanical adaptation and behaviour of soft tissues following lower limb amputation. In conjunction with interface sensors[4], this will provide evidence to inform socket design and amputee gait rehabilitation.

Acknowledgements

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References

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