IJAE
Vol. 117, n. 2 (Supplement): 134, 2012
ITALIAN JOURNAL OF ANATOMY AND EMBRYOLOGY

Structural conformation and mechanical testing of human crural fascia

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Chronic exertional compartment syndrome (CECS) is a condition in which chronic increased pressure within a closed osteofascial compartment compromises blood flow to the muscles and nerves within that compartment, resulting in pain and disability. It is frequent in athletes that occur in repetitive loading, as in competitive athletes, long-distance runners, skiers, basketball and soccer players. It is known that one of the possible cause is that the aponeurotic fasciae, as the crural fascia, in some subjects are not able to adapt to the variation of tension. Really, the mechanical behaviour of the fasciae is actually unknown.

Ten dissections of inferior limbs were performed to analyze the crural fascia from an histological (H-E, azan Mallory, van Gieson stains) and mechanical point of view (Planar Biaxial TestBench Test Instrument of Bose® Electro-Force), to understand its structural conformation and mechanical behaviour. The samples were cut along both the proximal-distal direction and the medial-lateral direction, in order to obtain evidence of possible anisotropy of the tissue. Both the anterior and the posterior compartments of the crural fascia were object of investigation. The samples had width of about 3 mm, a free 'gauge' length of 10 mm and variable thickness according to the location. The mechanical characterization of the elastic response of the crural fascia was made by considering tensile tests at a strain rate of 120%/s. The visco-elastic response of the fascia was evaluated by incremental relaxation tests at nominal strain of 7%, 9% and 11%, respectively. The stress decay of the relaxation tests was monitored for 240 s.

In crural fascia the collagen fibres are disposed to form three distinct sub-layers (mean thickness 115μm), separated by a layer of loose connective tissue (mean thickness 43μm). Inside a single sub-layer, the fibres are all parallel, whilst the angle between the fibres of adjacent layers is about 78°. Elastic fibres are less than 1%.

The tissue of the anterior compartment was found stiffer than the tissue of the posterior compartment, both along the proximal-distal and the medial-lateral direction. The tissue was found stiffer along the proximal-distal direction than along the medial-lateral direction. The stress decay during the relaxation tests was found similar for the anterior and the posterior compartment.

The preliminary results show that the crural fascia has structural conformation and mechanical properties that well adapt to the geometric variation of enveloped muscles. This is due above all to the spatial arrangement of collagen fibers. Besides, this fascia is not an homogeneous tissue, but it is stiffer anteriorly. This finding well corresponds to the clinical practice, indeed the anterior compartment syndrome is more frequent than the posterior one.

Keywords: Crural fascia, tissue mechanics, experimental testing, anisotropy.