The influence of plantar fascia and Achilles tendon load on human heel pad deformation: an in-vitro investigation

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BACKGROUND Recent anatomical investigations provide evidence that the network of fibrous septa within the heel pad is anchored to the Achilles tendon and plantar fascia, indicating a close functional integration [1]. The findings give good reason to hypothesize that tension of the Achilles tendon or plantar fascia influences heel pad deformation. In this study we aimed to find experimental evidences proving the concept of a functional integration between Achilles tendon, plantar fascia and heel pad.

METHODS Heel pad deformation of ten below-knee cadaver specimen was recorded using an uniaxial testing machine and high-resolution ultrasound simultaneously (Fig. 1). The setup allowed heel pad deformation to be differentiated from foot displacement in a range from 10 to 680 N at 134 N/s. Heel pad deformation was analyzed for a total of 10 loading scenarios, with five gradually increasing Achilles tendon loads (0, 50, 100, 150, 200 N) in combination with two plantar fascia conditions (intact and transected). Maximum heel pad deformation and horizontal dislocation of the heel pad were analyzed and compared statistically.

RESULTS Heel pad deformation was primary influenced by Achilles tendon load. At maximum axial load and an intact plantar fascia the heel pad deformation increased up to 28.6% with increasing Achilles tendon load (0 N: 1.75 ± 0.56 mm; 200 N: 2.25 ± 0.60 mm). Heel pad deformation decreased after transection of plantar fascia at 0 N Achilles tendon load but this effect vanished with increasing Achilles tendon loads. The ultrasound measurements uncovered an additional horizontal dislocation of the heel pad. The dislocation was most pronounced when no Achilles tendon load was applied (0 N: 4.23 ± 2.39 mm; 200N: 1.76 ± 1.90 mm). Transecting the plantar fascia had no further effect.

CONCLUSIONS Our study provides first experimental evidences proving the concept of a functional integration mainly between Achilles tendon and heel pad. The underlying explanations might be manifold and remain unclear. The Achilles tendon may interact directly with the heel pad via the fibrous network of the heel pad. Another explanation could be a horizontal dislocation of the heel pad and its consequences on the mechanical properties. Both approaches have barely been considered in previous studies but might contribute to raise awareness of the contribution that this findings might have in hindfoot biomechanics and possible treatment options.

[1] Shaw, H.M., Vázquez, O.T., McGonagle, D., Bydder, G., Santer, R.M. & Benjamin, M. (2008). Development of the human Achilles tendon enthesis organ. *Journal of Anatomy, 213* (6), 718–724.

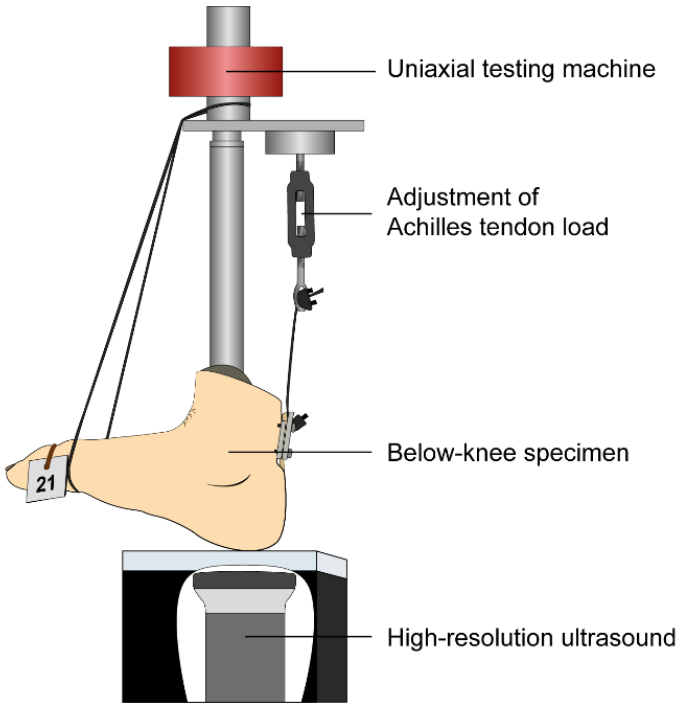

Fig. 1: Experimental setup.