Editorial: Tendon Structure-Function Relationship in Health, Ageing, and Injury

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Editorial on the Research Topic

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Tendons connect muscle fibers to the skeleton and, thereby, serve as transmitters of muscle force. Through their viscoelastic properties, tendons can store and release energy during movement contributing to the performance of motor tasks including locomotion. In contrast to the representation of tendons in textbooks and models of the musculoskeletal system, tendons are not simple viscoelastic bands, but are intricate multi-stranded structures. The objective of this Research Topic was to bring together studies aimed at improving our understanding of the tendon structure-(dys)function relationship in health and disease, with a particular interest in tendons linked to multiple muscles. All but one (Audenaert et al.) of the contributions investigated the Achilles tendon (AT), which is contiguous with the soleus and lateral and medial gastrocnemius muscles. Several other tendons arise from multiple muscles, such as the patellar tendon, and would be equally interesting to investigate.

Using a simulation approach, enhanced lengthening of the M. Psoas major tendon was found to be related to a rotational variant in human femoral morphology (Audenaert et al.). The influence of the skeletal system on AT mechanical properties was also indicated as a factor explaining the lack of tendon adaptation to mechanical loading during growth in a guinea fowl model (Katugam et al.). These studies exemplify the importance of assessing tendon behavior and adaptation within an integrated framework, such as described by Pizzolato et al.

Ultrasound imaging has been frequently used to study the differences in displacement of the deep and superficial portions of the AT (e.g., Arndt et al., 2012; Slane and Thelen, 2014). Internal tendon tissue displacements were more uniform when an ankle foot orthosis was applied and when the range of motion was reduced (Froberg et al.). A simulation study also reported that the amount of sliding between subtendons was task specific (Handsfield et al.). They further found effects of subtendon twisting and connectivity between subtendons. Tendon tissue displacements were found to be less uniform when subtendons were substantially twisted (Knaus and Blemker). Important for the ultrasound-based assessment of non-uniform displacements, a twisted morphology of the AT was also found to result in errors when estimating local strains. Regarding the connectivity between subtendons, clear evidence of force transmission via the inter-subtendon matrix was provided for rat AT (Gains et al.). Previous studies have demonstrated effects of aging on the mechanical properties of tendon (Sprague et al., 2020), its matrix (Thorpe et al., 2015) and non-uniformity of tendon tissue displacements (Franz and Thelen, 2015). In this Research Topic, it was shown that the structure-function relationship between the AT and the triceps surae muscles is disrupted in older adults (Knaus et al.). Using shear wave tensiometry to assess AT forces, differential effects of age on work...
performed by the soleus and gastrocnemius were observed (Ebrahimi et al.). While this method does not allow assessment of forces of each of the subtendons, such effects of age may also be related to the changes in mechanical independence between subtendons.

It is evident from the articles in this topic that the notion of subtendons in the human Achilles tendon, as introduced recently (Handsfie...d elongating the tendon cross-sectional area. More sophisticated imaging or analysis routines (see for example Handsfield et al.) are warranted to investigate the extent to which boundary regions exist within longitudinal tendon tissue displacement fields that could signal the presence or refute the premise of individual subtendons, per se. We therefore suggest that caution be exercised and the state of the science be acknowledged when using the term subtendon to investigate and/or describe internal human AT tissue function.

Sliding within the AT may be necessary to allow muscles crossing one (soleus) or two joints (gastrocnemius) with distinct activation patterns (Moritani et al., 1991) to function normally, and lack of sliding may be a sign of malfunction (Fraz...