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Achilles tendinopathy alters the link between muscle force-sharing and subtendon non-uniformity

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INTRODUCTION:
The Achilles tendon is the strongest and largest tendon in the human body and is connected and mechanically loaded through the force production of two individual muscles: the soleus (SOL) and the gastrocnemius (GAS). These muscles have shown independent actions on each subtendon with differential muscle force-sharing strategies [1] . Additionally, at the level of the Achilles tendon non-uniform displacement between tendon layers has been identified with the use of ultrasound speckle tracking [2]. The aim of this study was to investigate the influence of Achilles tendinopathy (AT) on the muscle-tendon interaction.
METHODS:
Eight participants (4 AT: 1F & 3M, 4 healthy: 4M) performed a submaximal contraction (30%) of their maximal torque generating capacity with the foot fixated in 5 degrees of plantar flexion in neutral, abduction and adduction positions, while collecting intratendinous displacement by ultrasound speckle tracking. To gain insights into the muscle force distributions, dynamic bilateral heel raises -neutral, abduction and adduction positions- were performed. Triceps surae muscle forces were analyzed at 5 degrees of plantar flexion through experimentally measured kinematics and kinetics, and a dynamic optimization method (musculoskeletal modelling). The muscle-tendon interaction was estimated by the ratio between muscle force-sharing (SOL-to-GAS contribution) and the relative subtendon displacement (deep-to-superficial). A value of 1 means that the imbalance of force produced by the SOL compared to the GAS generated a similar imbalance of intratendinous displacement. Shifting away from 1 represent a larger (<1) or smaller (>1) non-uniformity within the tendon compared to the muscle force imbalances.
RESULTS:
An altered muscle-tendon interaction was found between the AT group and the healthy group. Patients with AT show more Achilles tendon non-uniformity than muscle force-sharing imbalances in the neutral (0.76 ± 0.36 [AT]; 0.86 ± 0.10 [healthy]), abduction (0.46 ± 0.21 [AT]; 0.81 ± 0.17 [healthy]) and adduction (0.97 ± 0.44 [AT]; 1.34 ± 0.42 [healthy]) positions. At the tendon level, less relative subtendon displacement was present in the AT group for all positions: neutral: 1.01 ± 0.23 mm [AT] vs 1.98 ± 1.28 mm [healthy], abduction: 1.31 ± 0.57 mm [AT] vs 1.50 ± 1.24 mm [healthy], and adduction: 1.60 ± 0.56 mm [AT] vs 1.99 ± 1.21 mm [healthy]. Additionally, a lower SOL-to-GAS contribution was found in AT (1.34 ± 0.92) compared to the healthy group (1.66 ± 0.58).
CONCLUSION:
Patients with AT have less intratendinous shearing leading to an altered interaction of the muscle force-sharing and the pathological Achilles subtendons, which are known to function independently and individually. The influence of other factors on Achilles tendon functioning, such as the subtendon twist or the subtendons' mechanical properties remain unknown.
REFERENCES
[1] Crouzier et al. (2020) Med Sci Sports Exerc. 52(5):1076-1087
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