SEX DIFFERENCES IN BIOMECHANICAL PROPERTIES OF THE ACHILLES TENDON MAY PREDISPOSE MEN TO HIGHER RISK OF INJURY

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Background

- The Achilles tendon (AT) is the thickest, strongest tendon in the human body with the ability to store and release elastic energy during activity
- AT variations in lengths, thickness, and cross-sectional area (CSA) affect degeneration and pathology
- Men are two to eight times more likely to rupture their AT, but it is unknown if sex-specific variations in connective tissue morphology affect the rate of AT injury

Objective

The aim of this study is to systematically review the literature to determine if there are sex-specific differences in AT morphological and mechanical properties and analyze how these may impact AT injury in both men and women.

Study Characteristics & Eligibility

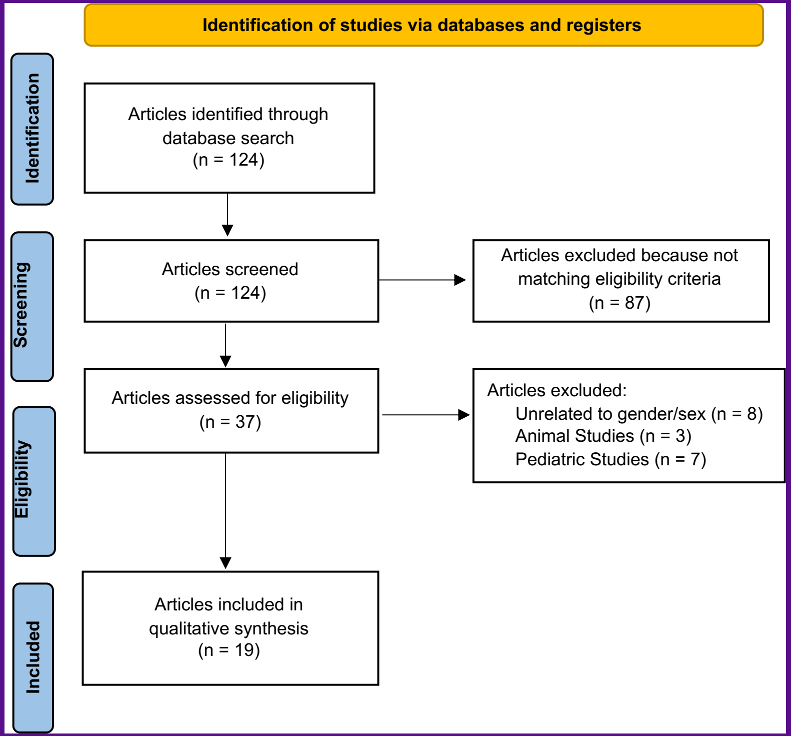

Fig 1. Identified 19 studies with 1,143 participants – 613 men and 530 women.

- Literature search in MEDLINE, EMBASE, and Cochrane databases following inclusion and exclusion criteria
- Primary outcome measures included AT length, thickness, cross-sectional area (CSA), stiffness, peak force, loading rate, and voluntary muscle contraction
- Secondary outcome measures included impact of sex on AT properties and adaptation

Results

Tendon Stiffness Outcomes	Male versus Female	Reference
AT Stiffness	M>W M=W	9–12 3
Gastroc/MG Stiffness	M>F	9,11,13
Globular angular joint stiffness	M>F	14
Series elastic component of plantar flexors - Passive	M>F	14
Series elastic component of plantar flexors - Active	F>M	14

Fig 2. Higher stiffness in AT, gastrocnemius, and globular angular joint in men

Fig 3. All six studies found increased force, torque, and moment in men.

Force Outcomes	Male versus Female	References
Plantarflexion Torque (PT)/Moment	M>F	12,15–17
Peak Achilles Tendon Force	M>F	1,12
Peak Achilles Tendon Stress	M>F	12
Hysteresis	M=F	12
Achilles Tendon Load	M>F	15
Achilles Tendon Loading Rates	M>F	15
Triceps Surae Moment Arm	M>F	14
Maximum Voluntary Contraction	M>F	14
AT-CSA at rest and during contraction	M>F	16
AT-CSA Deformation/Strain/Compliance	F>M	16

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Results

- Higher CSA, AT Thickness, AT stiffness, gastrocnemius thickness, globular angular joint stiffness values in men
- Increased elastic component of plantar flexors, peak AT stress, AT load, maximum voluntary contraction in men
- CSA deformation, strain, and compliance higher in women

Achilles Tendon Length Outcomes	Male vs. Female	Reference
Pennation Angle	M>F	9
Achilles Tendon Length	M>F	9,12,18
Medial Gastroc Fascicle Length	M=F	9
Variation of tendon properties between medial and lateral aspects of the Achilles Tendon	M=F	3
Cross Sectional Area	M>F M<F	9,12,18,19 20
Thickness	M>F M<F	9,12,14,18,19 20

Fig 4. All studies reported larger AT length and pennation angle in men. Four of six studies reporter a larger CSA and thickness in men.

CONCLUSIONS

- Increase in length, pennation angle, thickness, stiffness and CSA in men indicate an increased adaptation of force generation capacity and decreased ability to withstand repetitive stress
- Higher values of AT force and torque demonstrate increased stress, strain, and CSA in tendon adaptation to daily mechanical loads, explaining why men may be biomechanically subjected to higher loads in day-to-day activities
- The combination of higher CSA deformation, lower tendon stiffness, lower hysteresis, and smaller tendon size allows for women to have a more compliant tendon with better adaptation of loading
- Men may be subjected to higher daily loading with reduced capacity to adapt increasing risk of injury

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