How do Differences in Achilles' Tendon Moment Arm Lengths Affect Muscle-Tendon Dynamics?

MOUNT ROYAL UNIVERSITY 1910

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INTRODUCTION

- The Impact of the Achilles Tendon Moment Arm (AT_{MA}) on the energy cost of running (E_{run}) has been disputed:

Short AT_{MA}

- reduces E_{run} by:
  - Reducing muscle fascicle shortening velocity for a given joint rotation
  - Reducing active muscle volume
  - Reducing muscle energy cost
  - Higher tendon strain energy storage
- Increases E_{run} by:
  - Increased muscle forces for a given joint moment.

Long AT_{MA}

- reduces E_{run} by:
  - Reduced fascicle force for a given joint moment
- Increases E_{run} by:
  - Higher shortening velocity for a given joint rotation.
  - Reduced AT energy storage

PURPOSE

- To assess differences in muscle and tendon dynamics as a function of AT_{MA} length
- To determine the relationship between AT_{MA} and E_{run}

METHODS

Table 1. Subject Characteristics

N =	Age (yrs)	Height (m)	Mass (m)
19	24±3	177±7	75±11

- Participants were classified based on AT_{MA} length: 'LONG' (n=9, 36.6±2.5mm) and 'SHORT' (n=10, 29.5±1.8mm) from the bimodal distribution of AT_{MA} (p<0.001) (Figure 1)

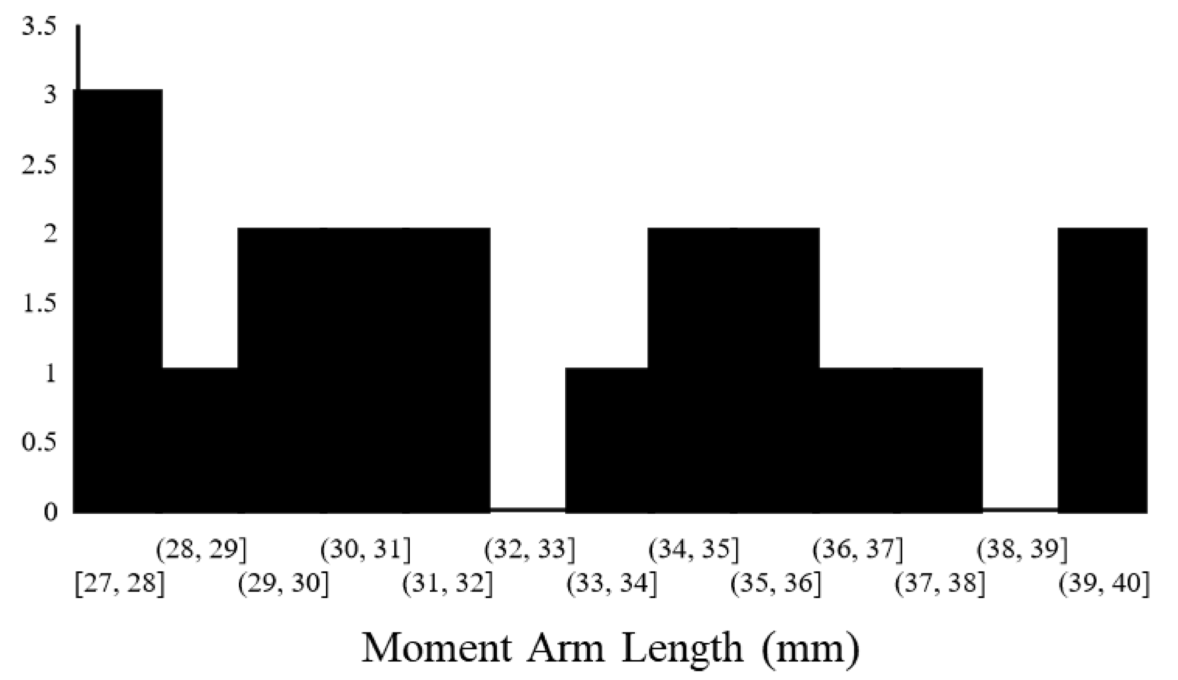


Figure 1. Frequency Histogram for AT_{MA}.

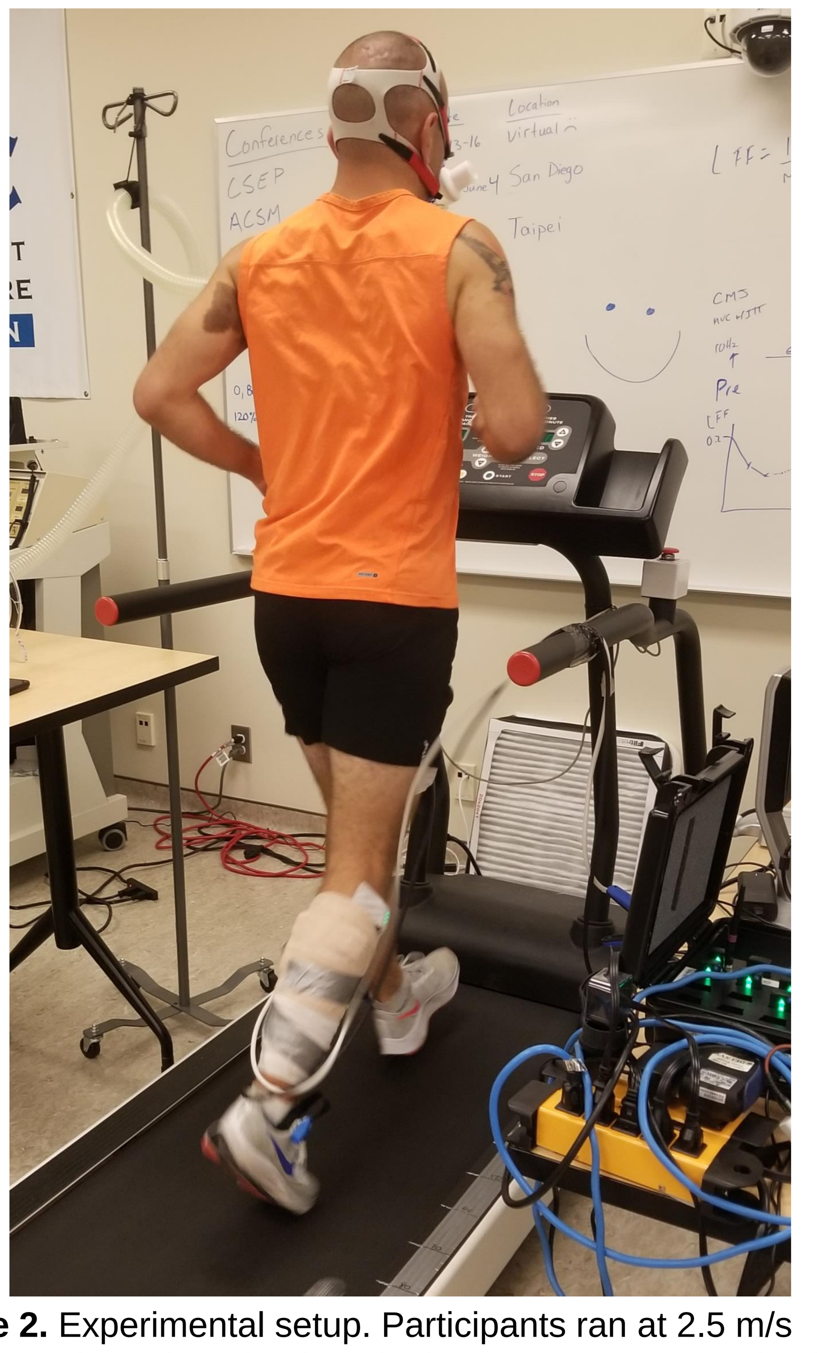


Figure 2. Experimental setup. Participants ran at 2.5 m/s while muscle and tendon length change was measured using ultrasound.

RESULTS

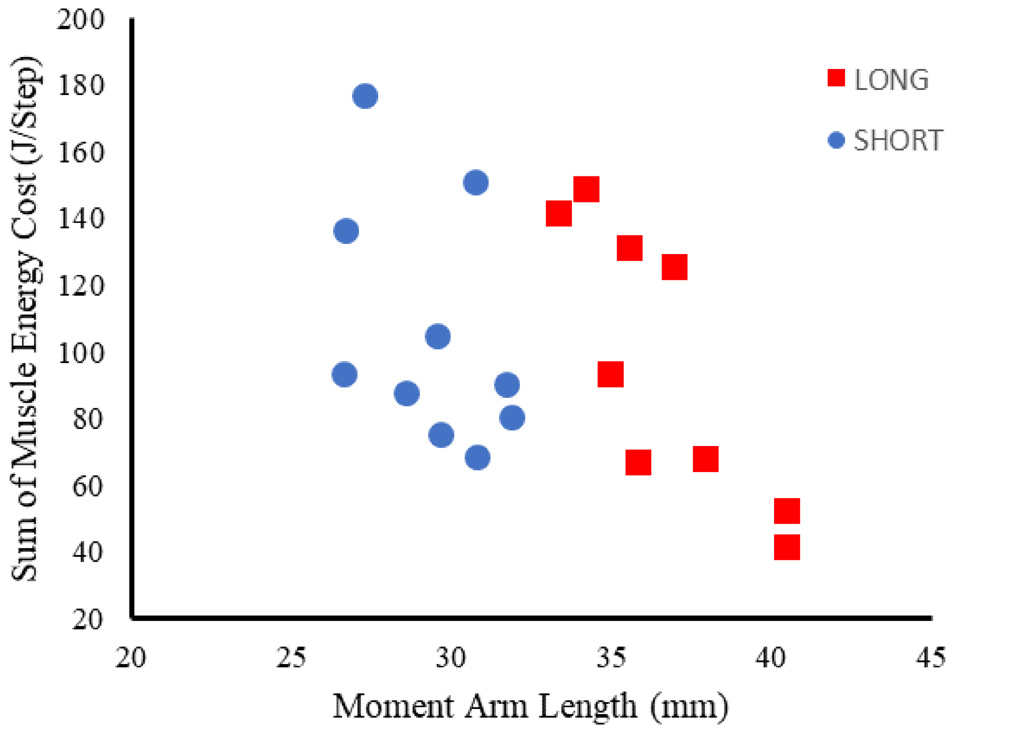


Figure 3. Relationship between estimated sum of muscle energy cost and AT_{MA}

- LONG AT_{MA} was significantly related with a reduced muscle energy cost (r^2=0.13, p=0.02) (Figure 3).
- Muscle forces were not significantly difference during stance phase (Figure 4)
- Fascicle length change, and fascicle force were not significantly different during stance (Figure 5)
- Shortening velocity was significantly higher in LONG (0.02±0.19 $L_f \cdot s^{-1}$) compared to SHORT (0.04±0.06 $L_f \cdot s^{-1}$) at 5% of stance (p=0.03, d=1.097) (Figure 6)
- There was a large effect size for 60% of stance (p=0.51, d=0.966) (Figure 6)

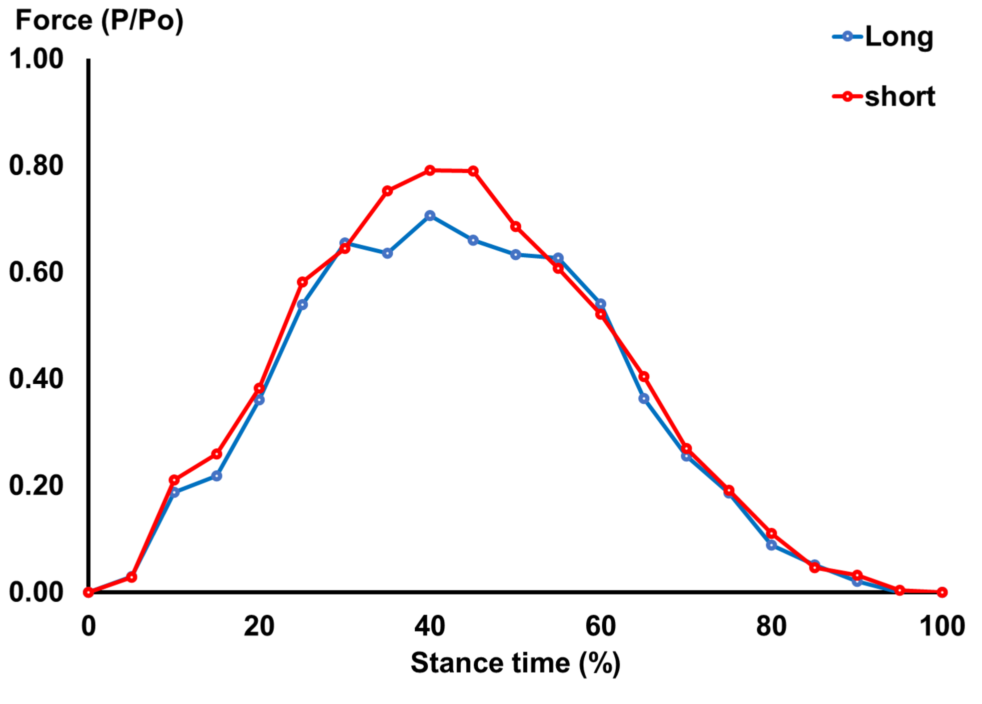
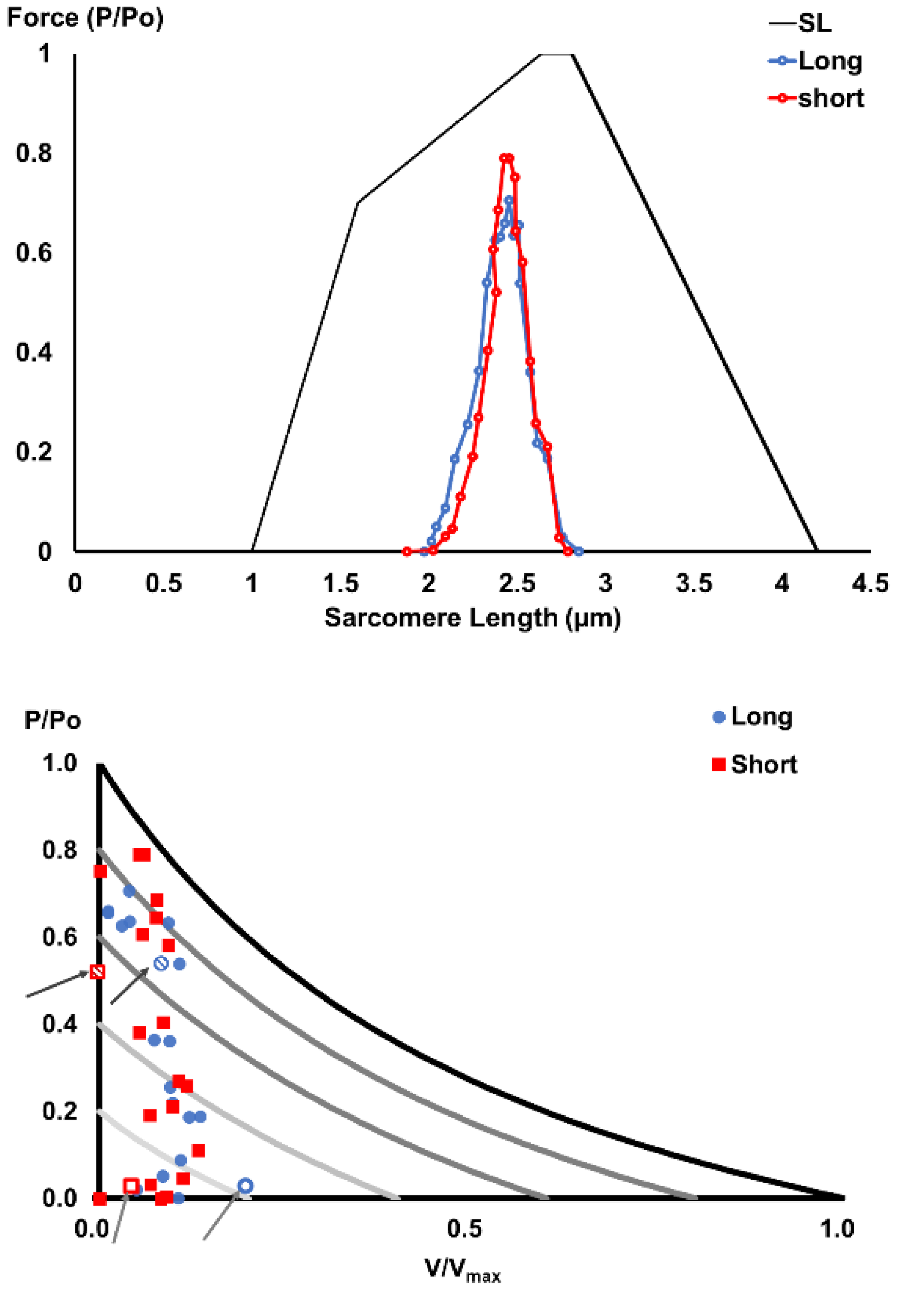


Figure 4. MG Force for both LONG and SHORT groups during the stance phase.

RESULTS



Figures 5. Operating range on the force-length relationship (TOP) and force-velocity relationship (BOTTOM) for SHORT (red) and LONG (blue) ATMA.

CONCLUSIONS

- LONG AT_{MA} was associated with a lower muscle energy cost, but we did not see differences in force between groups.
- The reduced muscle energy cost can be attributed to the lower shortening velocities between groups.
- Runners with short AT must have had a reduced plantarflexion moment, as a result of a reduced forefoot length.

ACKNOWLEDGMENTS

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