Dynamic changes in Achilles tendon moment arm during loaded conditions

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Summary

Considering the challenges in estimating the Achilles tendon moment arm, usually 2-D approaches have been deployed in resting conditions to obtain proxy values. However, less information can be found on the angle-moment arm characteristics during dynamic movements. Therefore, in this study, we used dual fluoroscopy imaging to capture the foot bone movements in 2-D during walking to estimate the length changes that occur in the Achilles tendon moment arm. We found similar parabolic angle-length characteristics as in previous reports using static images. The variance between individuals was high; therefore, we could not use a predictive model to estimate ATMA length at a specific angle in 2-D with high accuracy.

Introduction

Achilles tendon moment arm (ATMA) is often estimated by 2-D methods which are simplified approaches and are considered valid as a proxy value to characterize the length of ATMA at rest. These estimations are often performed in static and unloaded conditions. The joint dependent characteristics of the ATMA is often described as a parabolic curve indicating that ATMA length decreases as the ankle moves toward more dorsiflexed angles and it increases to a plateau with increasing plantar flexion. Because most of these results are based on extrapolated data estimated at certain joint angles, a more detailed data in active and loaded conditions is necessary to establish to understand the validity of previously identified ATMA-angle characteristics.

Methods

Ten male university students (age: 23.8±3.4 yrs; bm: 76.5±11.6 kg; bh: 177.7±5.0 cm) performed walking while dual fluoroscopy imaging scans were acquired from their right foot. DFIS featured two X-ray source and detector pairs arranged perpendicularly to each other and 30 images per second were captured during the measurements. ATMA length was estimated using a modified 2D method proposed by Wade et al. (2021), in which sagittal images were analyzed (Fig. 1.). ATMA was normalized to calcaneal bone length.

Results and Discussion

The mean ATMA at 90º was 5.20±0.97 cm (Fig 2.). The average decline in ATMA length at 8.5º dorsiflexion was 4.70cm (10% reduction), and the peak length was 5.88cm observed at 34º plantarflexion (13% increment). ATMA angle-length characteristics showed a parabolic curve which can be described with a second order polynomial curve (R^2=0.519), although the individual variability was high.

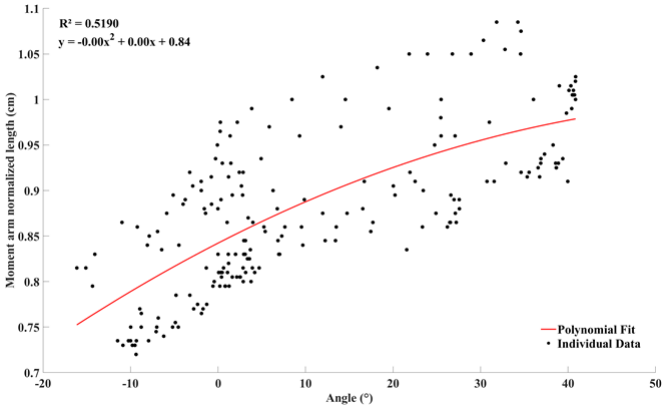

Figure 2: Achilles tendon moment arm length plotted against ankle joint position. Black dots indicate individual data points at the given ankle joint angle, and the red line represents the quadratic model fitted over the data points.

Conclusions

The angle-length characteristics of the ATMA observed in this study is similar to previously reported results, confirming that under loaded conditions the relation between ATMA and ankle angle is parabolic. However, inter-individual variability is high, therefore we could not use a predictive model to estimate ATMA length at a specific angle in 2-D with high accuracy.

References

[1] Rasske et al. (2017). *Comput Methods Biomech Biomed Engin*, **20**: 201-205.
[2] Wade et al. (2021). *J Orthop Res*, **39**: 572–579.