# Comparison of Achilles tendon stretch and running economy between novice and advanced marathon runners

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## Summary

This study compared the Achilles tendon stretch and running economy between novice and advanced marathoners. Eleven runners were recruited for each group. They performed three 10-minute treadmill trials at speeds of 9, 11, and 13 km/h respectively, during which the Achilles tendon movements were tracked by ultrasound imaging and reflective markers. A metabolic cart was used to measure gas exchanges. Advanced runners exhibited significantly lower energy expenditure than novice runners across all speeds. Although lacking statistical significance, Achilles lengthening and shortening appeared to be higher in advanced runners. The superior running economy in advanced runners may be attributed to more effective energy storage and return in the Achilles tendon. A firmer conclusion should be based on accurate energy calculation by factoring in tendon stiffness and tissue geometry.

## Introduction

As a key predictor of marathon performance, running economy is closely linked to energy recycling in the muscle-tendon units. The Achilles tendon, for example, plays a pivotal role in this process. The range of Achilles stretch largely determines the volume of energy storage and return in a gait cycle [1]. High Achilles stretch reduces the muscle work and energy cost for forward propulsion [2]. Individuals with a greater energy storage capacity of the Achilles tendon were found to deliver better race performance. It is speculated that the Achilles movement and running economy should vary among runners of different competitiveness. This study aimed to provide evidence to support this statement by comparing the Achilles tendon stretch and energy expenditure between novice and advanced marathon runners.

## Methods

Eleven novice marathoners (finish time > 4 hours) and eleven advanced marathoners (finish time < 3 hours 30 minutes) were recruited based on their race results over the past three years. In session one, the runners' resting Achilles tendon lengths were measured by ultrasound scanning (Telemed). In session two, the runners performed three 10-minute running trials on a treadmill at speeds of 9 km/h, 11 km/h, and 13 km/h respectively. The ultrasound probe was attached to the calf muscle to track the movement of the myotendinous junction. Reflective markers (Vicon) were placed along the Achilles tendon to facilitate calculating its stretch during gait. A metabolic cart (Cosmed) gauged breath-by-breath pulmonary gas exchanges. Data from the last 2 minutes of each trial were used to derive the outcome variables: Achilles tendon lengthening/shortening during the stance phase and energy expenditure. A MANOVA was applied to examine the results.

## Results and Discussion

MANOVA reported significant main effects of group ($F(1,9) = 4.17$, $p = 0.037$) on measures of energy expenditure, with advanced runners exhibiting lower energy expenditure at all speeds compared to novice runners ($p = 0.005$—$0.027$, Figure 1). Although not statistically significant ($p = 0.938$), there was a trend showing that both Achilles lengthening and shortening were higher in advanced runners. These findings suggest that advanced runners possess better running economy than novice runners. The greatest advantage in energy efficiency for advanced runners was observed at the speed of 11 km/h, implying that runners are metabolically most adapted to their usual pacing. Tendon stiffness and tissue geometry could also influence energy storage and return in the Achilles tendon. Future studies should account for these factors.

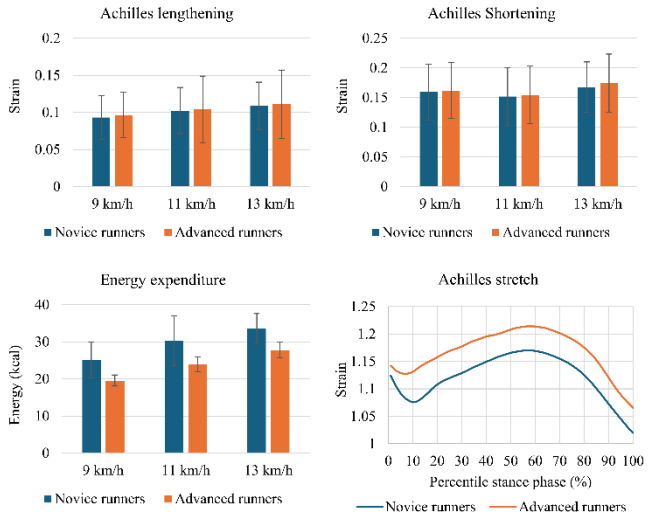


**Figure 1**: Comparisons of the outcome variables between groups and Achilles stretch during the stance phase at 11km/h.

## Conclusions

Advanced marathoners exhibit superior running economy compared to novice marathoners. Incorporating material properties and geometry of the muscle-tendon unit should improve the accuracy of quantifying energy recycling.

## References

[1] Fletcher JR et al. (2015). *J Appl Physiol*, **118**:193–199.
[2] Esposito M et al. (2022) *Sci Rep*, **12**(1):4193.
[3] Arampatzis A et al. (2006). *J Exp Biol*, **209** (17): 3345–3357