Effect of Running-Induced Fatigue on MRI-Derived T_2* Values of Achilles Tendon and Ankle Biomechanics in Novice and Experienced Runners

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Summary

The Achilles tendon (AT) is prone to overuse injuries. Magnetic resonance imaging (MRI) in this study was used to measure free AT T_2* value, while a 3D force platform combined with a motion capture system was used to quantify ankle mechanics during running before and after fatigue. The results showed that experienced runners had a significantly higher T_2* value one day after fatigue than novice runners. Novice runners exhibited a significant increase in ankle joint contact angle and maximum angle after fatigue. The findings indicated that experienced runners were more prone to AT injuries after fatigue, while novice runners demonstrated a lack of proper movement control and coordination.

Introduction

Long-distance running is a common cause of Achilles tendinopathy, particularly for novice runners, whose injury risk is 17.8%, with an AT injury rate of 7.8%, significantly higher than that of experienced runners [1]. MRI as a reliable method in clinical practice, has been used to assess the morphological characteristics of the AT; however, few studies have integrated these with the joint mechanical properties during running. Thus, this study aimed to compare the AT morphological characteristics and ankle mechanics before and after fatigue running between novice and experienced runners.

Methods

Sixteen healthy male runners (8 novice, 8 experienced) aged 18–26 years were recruited. Participants ran on a treadmill with speed increasing by 1 km/h every 2 minutes until reaching a Borg scale level of 13, then maintained the speed until achieving a Borg scale of 17, 90% of maximum heart rate, and VO_{2max}, at which point they were considered fatigued and stopped after 2 minutes [2][1]. Ankle joint angles and moments were measured before and after fatigue using a 3D motion capture system (Vicon, UK) and force platform (Kistler 9281B, Switzerland) at 12 km/h. MRI scans were performed on a clinical 3T MRI scanner (Prisma 3.0T MRI, Germany) one day before, one day after, and one week after the fatigue protocol. Two radiologists independently delineated the regions of interest on the AT MRI image and its three subregions (MTJ as the tendon-muscle junction; MID as the mid-tendon segment; INS as the tendon insertion segment) to calculate T_2* values. A 2×2 two-way ANOVA was used for ankle joint mechanics analysis and a 2×3 two-way ANOVA for T_2* value comparisons.

Results and Discussion

A significant interaction effect of running levels and time was observed for MTJ T_2* value (p = 0.027, **Figure 1A**). Post hoc analyses revealed that the MTJ T_2* value increased in experienced runners one day after fatigue and was significantly higher than in novice runners. A significant main effect of time was observed on maximum ankle angle during running (p = 0.02,**Figure 1B**). Moreover, a significant main effect of running level was observed on ankle contact angle (p = 0.031) and maximum angle (p = 0.025) during running (**Figure 1B**). No significant changes in ankle moment were observed in both groups (p > 0.05).

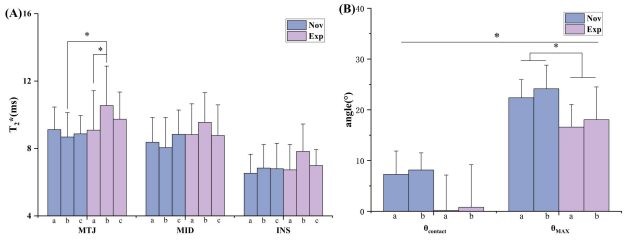

Figure 1: T_2* value of AT (A) and ankle joint angle (B) of novice runners and experienced runners before and after fatigue. *Indicates significant difference, p < 0.05. a, pre; b, post; c, post 1 week.

Although novice runners showed greater ankle joint angle variation during running due to a lack of proper movement control and coordination [2], experienced runners were more prone to micro-injuries in the AT after fatigue. However, with increased rest time, these microinjuries recover within a week.

Conclusions

The study found that novice runners experienced greater ankle joint angle variation during running due to a lack of proper movement control and coordination, while experienced runners exhibited higher MTJ T_2* values one day after fatigue, indicating microinjuries in the AT.

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References

[1] Videbæk S et al. (2015). *Sports Med*, **45**(7):1017-26.
[2] Koblbauer IF et al. (2014). *J Sports Sci Med*, **17**:419-424.
[3] Zhang X et al. (2018). *J Sports Sci Med*, **17**(4):640-649.