

The Effect of Advanced Footwear Technology Shoes on Lower Leg T2 Relaxation Time and Plantar Pressure

Lee Rou You¹, Keiichiro Hata¹, Yohei Yamazaki¹, Misato Ishikawa¹, and Toshio Yanagiya¹

¹Graduate School of Health and Sports Science, Juntendo University, Chiba, Japan

Email: rouyoulee@gmail.com

Summary

This study aimed to evaluate the fatigue level of the lower leg muscles in advanced footwear technology shoes (AFTs) compared to traditional shoes (TRADs) after running using T2-weighted magnetic resonance (MR) imaging, and to compare the plantar pressure between shoe conditions. Twenty-one male runners performed 10-min treadmill running at 18km/h, wearing TRADs and AFTs at two separate visits. Plantar pressure was measured during running for 1-min. Before and immediately after running, skeletal muscle proton transverse relaxation time (T2)-weighted MR images were obtained from the lower leg muscles to calculate the T2 values. T2 was significantly lower in the gastrocnemius medialis (GM) in AFTs compared to TRADs after running. Additionally, AFTs reduced the peak plantar pressure in the forefoot compared to TRADs. These findings demonstrated that AFTs significantly reduce the running exercise-induced increase in T2 in the GM, reflecting muscle fatigue, and alleviate peak plantar pressure at the forefoot during running.

Introduction

AFTs, characterized by a carbon-fiber plate embedded in the highly compliant and resilient midsole, has been reported to improve running mechanics and performance [1,2]. Despite many studies have confirmed the superior performance of AFTs, none have reported their impact on running-related injury risk. The etiology of running injury is multi-factorial but the most common overuse injuries are calf strains and metatarsal fractures, attributed to the increased load on the forefoot and the repetitive nature of running. An approach to measure the metabolic and fatigue state of individual calf muscles is to utilize T2-weighted MR imaging, which provide excellent spatial resolution [3]. Thus, this study aimed to evaluate the fatigue level of the lower leg muscles in AFTs compared to TRADs after running using T2-weighted MR imaging, and to compare the plantar pressure between shoe conditions.

Methods

Twenty-one male distance runners (age: 20.06±1.19y, weight: 57.7±3.9kg, height: 172.3±4.05cm, 5000-m personal record: 14:25±1:14min:s; mean±SD) performed 10-min treadmill running at 18km/h, wearing TRADs and AFTs at two separate visits. Plantar pressure was measured using the Novel Pedar-X system for 1-min at the start, then removed, followed by 10-min treadmill running. Before and immediately after running,

T2-weighted MR images were obtained from each individual lower leg muscles to calculate the T2 values.

Results and Discussion

A significant Shoes × Time interaction was observed in the GM ($p<0.05$, $\eta^2=0.067$) (Figure 1). Post-hoc statistical analyses revealed that after running, T2 increase was significantly lower in AFTs compared to TRADs in the GM ($p=.015$, $d=0.39$, -2.40%). It is likely that the highly compliant and resilient midsole in the AFTs stores and returns mechanical energy during each footfall, while the carbon-fiber plate acts as a lever, serving as the shoe sole's fulcrum, decreasing GM shortening velocity, and thereby reducing the fatigue level in the GM. Additionally, AFTs significantly lowered the peak plantar pressure in the forefoot compared to TRADs ($p<0.05$, $d=3.20$, -54.69%) (Figure 2). Since the carbon-fiber plate in AFTs acts as a first-class lever stiffening the metatarsophalangeal joint [2], thus we speculate that this joint stiffening mechanism could enhance rolling efficiency, potentially reducing forefoot pressure during running.

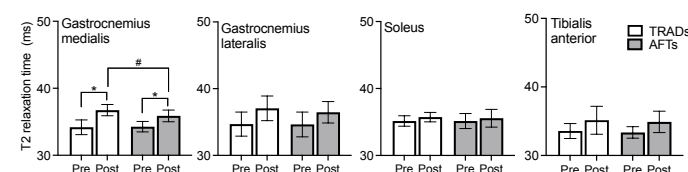


Figure 1. T2 of the lower limb muscles. *Significantly different between TARDs and AFTs ($p<0.05$) #Significantly different between shoe conditions after running ($P<0.05$).

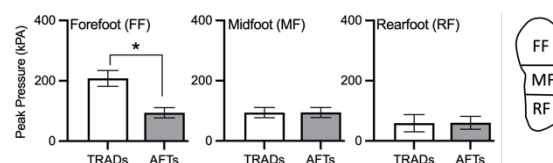


Figure 2. Peak plantar pressure across the foot region. *Significantly different between TARDs and AFTs ($p<0.05$).

Conclusions

These findings demonstrated that AFTs significantly reduce the running exercise-induced increase in T2 in the GM which reflect muscle fatigue, and alleviate peak plantar pressure at the forefoot during running, potentially reducing overuse injuries in long-distance running compared to TRADs.

References

- [1] Hoogkamer W et al. (2019). *Sports Med*, **49**: 133-143.
- [2] Nigg BM et al. (2021). *Sports Med*, **9**: 462-463
- [3] Goh SS et al. (2011), *Eur J Appl Physiol*, **111**:819-862.