# Effects of sex and footwear stiffness on lower limb running biomechanics

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## I. Introduction

Footwear longitudinal bending stiffness has been shown to affect a variety of running biomechanics and performance variables [1]. Even though footwear stiffness affects running biomechanics, the majority of studies have focused primarily on male participants [2]. However, it is known there are many differences between sexes such as body mass, lower limb muscle strength and size, and tendon stiffness, which could all influence running performance and how individuals adapt to footwear with different stiffness [3]. With respect to tendon stiffness, differences in the ratio of collagen fiber types, sensitivity to cellular signals, and total water content of tendons cause variation in tendon composition between sexes [3]. These sex-specific differences in tendon properties might influence how individuals adapt to footwear stiffness differently.

The aim of this study was to determine the sex-specific effects of running in footwear with different longitudinal bending stiffness on lower limb biomechanics.

## II. Methods

20 participants (10 male and 10 female) ran on a force-instrumented treadmill at 3.5 m/s in three different shoe conditions (Fig. 1). The shoe conditions were a minimalist shoe that was flexible and had either 1) no, 2) 1mm carbon fiber plate, or 3) 1.5mm carbon fiber plate to vary the longitudinal bending stiffness of the shoe. 23 retroreflective markers were placed over body landmarks and tracked using a 12-camera motion capture system. Participants ran for 30 seconds at each condition to assess a number of biomechanical running variables of the person's right leg.

Fig. 1 Three shoe conditions.

## III. Results and expected results

Increased footwear longitudinal bending stiffness is anticipated to decrease negative joint work and increase positive joint work at the MTP joint for both sexes compared to the control shoe. It is expected that metatarsophalangeal (MTP) moments will be significantly higher for males than for female runners. Males are expected to have stiffer tendons than females which have the potential to resist deformation or store more elastic energy during the loading or deceleration phase. Therefore, male runners are expected to exhibit a greater decrease in negative work and increase in positive work at the MTP joint compared to female runners when running in stiffer shoes. Additionally, increased footwear longitudinal bending stiffness is anticipated to decrease positive joint work at the ankle, knee, and hip joint for both sexes compared to less stiff shoes. Male runners are expected to exhibit a greater decrease in positive joint work at the ankle, knee and hip joint compared to female runners when running in stiffer shoes.

The results of this study are expected to contribute to the overall understanding of why and how different sexes adapt their running biomechanics based on footwear stiffness. This information will help shoe manufacturers design footwear that is specific for males and females.

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## References

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